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National Science Essay Contest . . .

Early announcement of the 1942 Duquesne University National Science Essay Contest is made so that Catholic high schools everywhere will have an opportunity to give increased thought and preparation to their entries.

All Catholic high schools which teach any of the sciences are invited to participate. In order that the greatest good may result from this competition, it is suggested that the essays entered in the national contest should be selected by means of contests in the individual schools.

The essays submitted in this competition will be judged by members of the faculty of Duquesne University. Form, content, and expression will be considered. A gold medal, for permanent possession, will be awarded to the writer of the best essay. Several honorable mentions will be made, the number depending upon the excellence of the essays submitted. A suitably engraved silver cup will be given to the winning school. The cup will be held for one year. It will then be passed on to the school receiving the new award. This cup is now in the possession of St. Joseph Academy, Yakima, Washington, the school which won the 1941 contest.

Announcement of the winner will be made in February, 1942. The prize essay will be published in full in the SCIENCE COUNSELOR. Only winning essays and schools will be announced. A list of the schools which enter the contest will not be published.

The rules which are to govern the contest are here given.

RULES FOR ESSAY CONTEST

Subject of the Essay: *Science Controls Household Pests.* No other subject may be used.

1. Any student enrolled in a Catholic high school, junior high school, or preparatory school, who has not yet completed four years of high school work, is eligible to enter this contest. It is not re-

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Growth by Cell Enlargement

● **By Brother William A. Beck, S.M., Ph.D.,** *(University of Freiburg)*
DEPARTMENT OF BIOLOGY, UNIVERSITY OF DAYTON, DAYTON, OHIO.

While you may not find this short paper easy reading, we feel that it deserves and should have your careful study. To the thinking biologist it may open new vistas.

Dr. Beck is an enthusiastic and successful research worker. Numerous reports of his researches on osmotic values, plant pigments, and growth phenomena have already appeared, and others will soon be published, in "Nature" (England), "Plant Physiology", "Science", "Transactions of the American Microscopical Society", "Studies of the Institutum Divi Thomae", and other journals.

The writer has been professor of biology at the University of Dayton since 1926. For the past six years he has also been a member of the staff of the Institutum Divi Thomae. Recently he has been carrying on and directing researches at the Institutum's new division at Palm Beach, Florida.

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Growth, which is a characteristic of organisms, has been defined as an irreversible increment in volume. Sachs described growth in plants in four stages: organization, differentiation, cell enlargement and maturation.

Organization and differentiation correspond to the zoologist's notion of growth, and involve cell proliferation and cell differentiation. Growth-promoting factors of the bios group stimulate these phases of growth. We are concerned with growth by cell enlargement, which is a characteristic of plants; it consists in an irreversible increment in the volume without appreciable increment in the mass of the protoplasm. It is stimulated by the growth-promoting factor auxin.

The increment of the dry weight in this kind of growth is mainly due to increased mass of the cell wall. The increment in volume is the result of water uptake which is a major factor in this kind of growth. The water uptake depends on the suction tension of the cell, which is given quantitatively by the suction tension of the cell sap less the wall pressure.

In 1874, Sachs theorized that the turgor within the cell caused it to enlarge. The results of other investigators failed to support his contention. In 1893, Pfeffer contended that with increased growth the turgor decreased and with growth inhibition, it increased.

In 1924, Ursprung and Blum proved beyond a doubt that the suction tension was maximum and the turgor minimum when growth was most vigorous. This made it certain that turgor could not be the major cause of growth by cell enlargement.

Already in 1893, Krabe advanced the theory that the wall grows actively. In 1928, F. W. Went proved that this kind of growth is induced by auxin, and, in 1931, he adduced satisfactory evidence that this growth-promoting substance increases the ductility of the wall. Recently Crafts proved that auxin is translocated in the phloem and moves predominantly in a basipetal polar direction. This explained the fact that in etiolated seedlings the lateral cell walls grow longer but the transverse walls hardly change their dimensions in this growth process. Borgström and others showed that external factors can influence the direction of the translocation so that the longitudinal walls grow less and the transverse walls become longer.

When the walls grow actively by intussusception the suction tension of the cell tends to increase because the wall pressure decreased, but the influx of water tends to dilute the cell sap so that, in time, both the turgor and the suction tension would be reduced to the limit beyond which the cell cannot support itself. This suggests the notion that some solute must be produced during the growing process. The present writer was able to prove experimentally that growing cells produce solutes at a rate which is proportional to the rate of growth. This makes it apparent that the growth of the wall and the production of solute are phases of growth, which proceed simultaneously so that neither the one nor the other may be regarded as the sole cause of growth.

It is difficult to conceive that a mere trace of the auxin should produce such profound changes in the wall and in the cell sap directly. It is probable that the effects are secondary. Went expressed the opinion that the auxin exercises its effect on the protoplast. In 1934, Strugger showed experimentally that significantly graded changes in the viscosity and colloidal state of the protoplasm occur during the process of growth. The characteristics of the protoplasm were distributed in the form of a "plasmatic gradient" in roots, shoots and leaves. The gradients were correlated with the physiological zoning. His results harmonized with the notion that the auxin influences the protoplasm, which might well be made responsible for the growth of the wall and the production solute.

From the experimental data, discussions and theories, the following scheme of growth by cell enlargement may be set up. The phytohormone auxin which is elaborated in the zone of cell proliferation, is translocated and exercises its effect upon the protoplasm.

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Light, Star Reporter of the Universe

• By George E. Davis, Ph.D., *(University of Minnesota)*
DEPARTMENT OF PHYSICS, DUQUESNE UNIVERSITY, PITTSBURGH, PA.

Cosmic news!

How is it transmitted? How do we get information about the universe beyond our earth?

Here is a story of light rays, incredibly swift reporters, whose news does not reach us until millions of years after the events described have occurred. This paper tells how men study the stars and learn their number and position in the sky, their size, how hot they are, how far away, how rapidly they move, and of what they are composed.

Perhaps you may have wondered at times about some of the things Dr. Davis here explains so clearly.

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The astronomer with his telescope, studying the planetary children of the sun and the myriad stars in the great spaces beyond, peers into the secrets of a universe too vast for even the wildest imagination to grasp.

Many devices have been used to impress us with the immensity of the universe, now known to be more than a hundred million light-years in extent. Perhaps the best device is to imagine it reduced to the size of an enormous room 3,000 miles long, 3,000 miles wide and 3,000 miles high. Such a room would cover most of the continent of North America, with its ceiling 500 times higher than the highest mountain peak. Somewhere in that room is our own great solar system with its nine planets swinging endlessly about the sun. The diameters of their orbits are measured in millions of miles, with Pluto farthest out in an orbit with an average diameter of 7,400,000,000 miles. Surely our solar system will be a pretty big thing, several miles wide at least, in this 3,000-mile model of the universe.

Then we make some calculations, based on our conservative assumption of a universe 100,000,000 light-years in extent, and we are astounded. Instead of an enormous thing, our solar system is only a tiny speck of nearly-empty space one four-hundredths of an inch in diameter! The sun and all the planets are in that speck, and all are invisible. Our enormous solar system is of no more physical significance in the universe than is a grain of sand in the mass of the entire earth. The earth itself is so small that even the new electron microscope, magnifying 100,000 diameters, would reveal not a trace of it. It is smaller even than the smallest known atom!

Yet in spite of this unbelievable immensity of the universe and the unbelievable physical insignificance of our earth, a tiny sub-atom of a man on that earth, with an instrument he has fashioned of metal and glass, manages to receive and interpret a continual stream of cosmic news of the ever changing activities of the billions of stars which form the principal material things in that universe.

How is this miracle possible? Only by virtue of the light rays which are emitted by the stars and which are passing continually through all the great interstellar spaces. These rays tell the astronomer many things. They tell him the number of stars and their positions in the sky. They tell him the brightness or luminosity of each star, its size, its distance from the earth, the chemical elements of which it is composed, its temperature and whether it is approaching the earth or receding from it. Light rays also reveal that millions of the stars are grouped in great clusters called nebulae and that some of these have the form of spirals, from which it would seem that they are slowly revolving, like particles in an eddy formed by a turbulent stream.

Thus, light is the great Star Reporter of the Universe. Only from the intelligence which it brings can man know that the universe extends beyond the little layer of atmosphere, a few miles thick, which he is able to explore.

This reporter is incredibly swift. It can circle the earth more than seven times in a second. In eleven hours it can travel entirely across our solar system (the orbit of Pluto), 7,400,000,000 miles. Yet even this transcendent speed is all too slow for the distances which must be covered in reporting cosmic news. If up-to-the-week reports are to be brought from the far reaches of interstellar space, then in our model of the known universe, a room 3,000 miles long and wide and high, our reporter must travel as fast as an automobile; or, at the slowest, as fast as a man can ride on a swift horse. But it cannot. With all its speed, it can travel, in an entire year, only about two inches! And so the news it can bring from the more distant nebulae is old news indeed. It is as if one waited in Chicago or Pittsburgh for news of the San Francisco earthquake, while the messenger crept across the interminable distances between at the rate of two inches a year, a mile in 32,000 years. Word of some great cataclysmic event that occurred in the life of a star 50,000,000 years ago may just now be arriving at the telescope of the astronomer. When that event occurred, the dinosaurs were here and many of our mountain ranges had not yet risen from the sea. Even news from the very nearest star is four years in arriving. If that star exploded a year ago last Christmas, flash-

ing out with a brilliance a hundred thousand times that of the sun, as other stars have done, we shall be in complete ignorance of it until Christmas, 1943.

We see the universe as it *was*, not as it *is*. The stars are not where they appear to be. The "big dipper" that we see is not there at all. Orion was a hunter eons ago but his heroic form has long since dissolved in the heavens. For all the stars are moving, not slowly but so swiftly that photographs of the sky, taken some years apart, reveal differences in their apparent positions. We are moving too, carried along by our own star, the sun. And so the configuration of a constellation or of the stars of a distant nebula may have changed entirely since that day in the geologic past when our star reporter tucked the picture of that configuration under his vibrating belt and set out on his long, long journey to the earth.

The nature of our star reporter is partly known, partly unknown. The brilliant experimental researches and theoretical work of many men during the last three hundred years have shown that light consists of vibrations, partly electric and partly magnetic, passing through the ether. These vibrations or waves are not continuous but are concentrated in separate units so as to form something like minute corpuscles composed of ether waves, traveling with the enormous speed we have mentioned. Huygens first clearly conceived and described the wave theory of light, 263 years ago. He assumed the waves to be continuous. Newton considered the theory of Huygens and after long and searching examination decided that the evidence for material corpuscles of light was stronger than the evidence for waves. Now we know that both Huygens and Newton were right but that the theory of neither was (nor could be expected to be) complete. Light consists of the corpuscles of Newton, but each has the wave structure postulated by Huygens. We now call these corpuscles "photons." Because of the vibrations within them, they are minute separate bits of energy.

These photons are no ordinary projectiles, viewed from any angle. No other particles can move so swiftly. They are not swerved from their paths by electric or magnetic fields. Once shot into the ether, they travel onward forever with no loss of speed or energy, unless obstructed by some material body. But while they are discrete units, each a free-lance of independent action, they are capable of the most amazing cooperation; for when they combine in enormous numbers, the mass effects are as if there were no separate particles at all, only a succession of continuous waves to which the mathematical relations worked out by Huygens and Young and Fresnel can be applied with great exactness.

Within the vibrations of these electromagnetic waves that constitute light is contained all the information which we receive from the universe beyond our earth. How the vibrations impart this information to the astronomer is now to be described.

Number and Apparent Positions of Stars

The number of stars and their positions and group configurations in the sky are shown by the angles at which the photons from those stars enter the telescope or the eye. But the positions of the stars thus revealed are only the apparent positions as projected onto the dome of the heavens, not the positions in space. To know the latter we must know also the distances of the stars from the earth.

Distances of the Stars

The distance of a star, if not too great, is shown by the difference between the directions of its rays as they approach the earth when the latter is in two widely separated positions in its orbit. These positions may best be taken on opposite sides of the orbit, 186,000,000 miles apart. The astronomer finds the direction his telescope is pointed when focused on the star from each of the two positions, at the same time of night, and so finds the angle between the directions. Half of this angle is the "parallax" of the star. Knowing the angle, the distance of the star can be found from the simple relations between the lengths of the sides of a triangle. But the stars are so far away that even the nearest one has a very small parallax, only 0.8 of a second of arc. Trying to measure this angle is like trying to measure, with a telescope, the diameter of a copper penny two miles away! For the more distant stars, the angles are many times smaller. To assist in measuring these minute angles, the apparent positions of the star are found with respect to some star so far away that its position does not appear to change at all.

But what about these more distant stars whose positions do not appear to change as the astronomer rides the swiftly moving earth around the sun? Their distances must be found by other methods, none of which can be used in all cases. One method is to compare the apparent brightness of the far distant star with that of a nearer star which has the same chemical composition and surface temperature and whose distance has been measured by its parallax. Similarity in chemical composition and in temperature is revealed by similarities in the spectra of the two stars. This will be explained later. A different sort of comparison of the spectra also reveals the difference in the sizes of the stars. Making allowance for this difference in size, the distances then are inversely proportional to the square roots of the apparent brightnesses, in accordance with the "inverse-square law," with which every student of elementary physics is familiar.

Another method of finding the distance of a remote star is given us by our star reporter, if that star happens to be one of the "Cepheid variables." These amazing stars vary in brightness with perfect regularity, like fire-flies flashing their lights to the rhythm of a celestial dance. It has now been revealed that the absolute brightness or luminosity of such a star varies in a definite manner with the time between its

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The World of Color

Part I. Light and Color

● By Isay A. Balinkin, Ph.D., *(University of Cincinnati)*
DEPARTMENT OF PHYSICS, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO.

This interesting and valuable article is the first of a series to be written for THE SCIENCE COUNSELOR *by a distinguished scientist who has the ability to present solid scientific facts in a pleasant "popular" manner that even the layman can understand.*

Wideawake teachers will find in this paper a number of teaching hints, useful methods of approach, helpful analogies, and good suggestions for demonstration experiments.

The articles to follow are entitled "How Do We See?" and "Color Measurements."

●

From the earliest days of the existence of the human race man has been conscious of color.

Archeologists tell us that the walls of the cave, the place of dwelling of the prehistoric man, show the first artistic venture of man into the art of coloring. In our everyday life we are so accustomed to color that very few of us stop to inquire the "why and wherefore" of its existence, or its cause.

Although the serious study of color must be reserved for those having the necessary knowledge of mathematics, physics, chemistry, and even physiology and psychology, a considerable amount of pleasure can be derived from the understanding of some simple aspects of light and color, in which experiments give results so fascinating and often so beautiful. There are many books which discuss this subject in popular language. Probably the earliest attempt to do so is a quaint book by Count Argarotti, F. R. S., published in 1765, which I was fortunate to add to my library a few years ago. The title of the book is *The Philosophy of Sir Isaac Newton Explained in Six Dialogues on Light and Color Between a Lady and the Author.* The author states in the introduction that "... mathematical figures are entirely excluded, as they would have given these discourses too scientific an air, and appeared formidable to those who . . . prefer the present *momentary* fashion of adjusting their head-dress and placing their curls . . . who had rather perceive than understand and who to be instructed must be pleased." In spite of the fact that these remarks were made more than 175 yeprs ago they are just as applicable today as they were then.

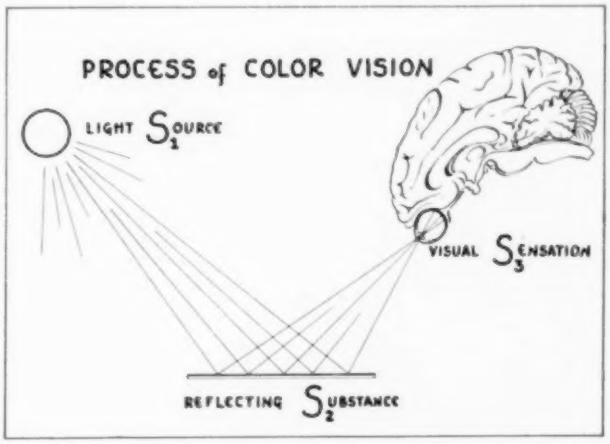
Today, color is an important factor in practically every article, not only of art, but also of commerce, and in industry and agriculture.

There are several different aspects to the study of color. To a physicist color means primarily radiant energy. The chemist employs the term color to designate the appearance of certain pigments or dyes. The physiologist and the psychologist are interested in understanding the nature of the visual process which gives us the sensation of color. And, finally, the artist is concerned with the aesthetic effect produced by arranging different colors in the most pleasing manner. In every case, however, what we see is the final criterion in establishing the meaning of color.

It must be realized from the very beginning that the appearance of a color does not depend only upon the chemical property of the reflecting surface. We must take into consideration also the kind of light source used for illumination as well as some physiological and psychological factors which enter into the process of vision. All these factors can be conveniently expressed by three words, each beginning with the letter S: namely, *source, substance,* and *sensation.* The appearance of any color can be entirely changed when any one of these is varied. Much confusion and slow progress in the science of color was due to, and still can be attributed to, the lack of realization that all three factors form an indispensable partnership.

In order to impress upon you this fact, I would like to perform before your eyes some striking demonstrations. For you as readers, I can offer only a brief description of these imaginary experiments.

To begin with, I have before me one glass filled with 1% solution of ordinary hydrogen peroxide into which I drop a few red crystals of potassium ferricyanide. The other glass contains a 2% solution of sodium hydroxide into which I put a small amount of yellow



powder, known as "luminol."[1] I grasp one glass in each hand and have the room completely darkened. I now pour the contents of the glasses simultaneously into a large flask. Immediately a brilliant yellow-green light appears as the two liquids mix. The illumination is sufficiently strong to read small print under this "liquid light." The source, substance, and visual sensation are all necessary to be able to observe this remarkably bright chemoluminescence. This light is very similar to the scintillations of fire-flies which you probably have observed many times on a dark night.

Let us see now to what extent the color depends upon the source. Here is an electric sodium vapor lamp which I switch on. It emits a bright yellow light, illuminating a cardboard on which we can distinguish a dozen circular discs. They all seem to be of the same yellow hue but of different brightness. The cardboard is now placed close to a bright source of white light and a remarkable change takes place in the appearance of the circular discs. Some of them acquired a bright red or yellow, and others green, blue or violet colors. These are the same discs which under the sodium lamp did not show anything but yellow.

The part played by our senses is no less important than that of the source or substance. Witness, for example, this demonstration in which a bright red lamp is placed behind a circular cardboard disc from which a sector has been cut out.[2] One-half of the disc is white, while the other half is black. The disc is mounted on a shaft so as to turn a few revolutions per second. As it turns we can still see the lamp through the sector cut in the disc. The surprising thing, however, is that the lamp no longer looks red,—it looks blue-green. Here our light source remained the same, as well as the substance of the red dye with which the lamp was painted. The only difference is that we changed the conditions of observation in such a manner that our sense perception responded not to the original stimulus of red, but to its complementary which is blue-green.

The beginning of the study of light in its relation to color can be very definitely traced to one bright and sunny day in 1666 when Sir Isaac Newton cut a small circular hole in the window-shade and placed a simple triangular prism in the path of the entering sunbeam. To his astonishment he observed not only the bending of the ray of light after it had emerged from the other side of the prism, but also that the edges of the spot were not sharp but presented, as expressed in Newton's own words, "vivid and intense colors."

The spectrum thus produced formed a continuous succession of seven colors: red, orange, yellow, green, blue, indigo, and violet. When all these colors are mixed in proper proportion the visual sensation of white is produced. Newton proved this fact by placing another prism behind the first in a reversed position which brought together these different spectral colors and gave a white spot. The reason why the prism forms a spectrum is simply explained by the fact that light of different colors travels in glass with different velocities. When a beam of light falls on the side of a prism in an oblique direction, differently colored rays composing white light are separated from each other. This may be compared to a cross-country run where every athlete carries the color of the club he belongs to—when we look at them while they run together with the same velocity, our eyes perceive nothing but white. But now they run into a muddy field—we see that those taking longer strides are able to forge ahead of their shorter competitors who are taking shorter steps and who are losing time in more frequent efforts to extricate their feet from the muddy ground. We are beginning to distinguish the colors of individual athletes as they disperse, because of their difference in velocity.

This analogy can be carried to a point of assigning to every color in the spectrum a very definite "length of stride" which determines its velocity in a transparent substance. The "length of stride" is called in physics the wavelength, and can be measured, in spite of its smallness, with an extraordinary precision. The unit of measuring the wave lengths is called the Angstrom Unit, which is equal to one one-hundredth of a millionth part of a centimeter. On this new scale, the range of violet color is from 4000 to 4600 Angstrom Units, blue from 4600 to 5000, green from 5000 to 5700, yellow from 5700 to 5900, orange from 5900 to 6100, and finally, red from 6100 to 7000 Angstrom Units. Within the limits set by 4000 and 7000 Angstrom Units lies the visible part of the spectrum,—a region to which our eye is "tuned," covering less than one octave of the radiant spectrum.

To give you an idea of how accurately these wave lengths are measured, I may mention that the red radiation emitted by the element cadmium is given by the number 6438.4696 Angstrom Units with a probable error of one part in 60,000,000—a precision which would require a distance of one mile to be measured with a variation no greater than the thickness of an ordinary cellophane wrapper. And this, in spite of the fact that there are about 40 of these waves within the thickness of that cellophane.

Nature itself occasionally performs for us the same experiment that made Newton immortal among scientists. I have in mind the rainbow which shows an array of color sequence similar to that produced by a prism. In fact, each small droplet of water-mist suspended in the air acts like a little prism and the rainbow is a synthesis of these small spectra produced by individual droplets of water. This leads me to an incident which occurred about one hundred years ago. At a dinner party given at the home of the English painter Haydon, the poet Keats, raising his glass, proposed a toast deprecating the name of Newton. When Wordsworth, astonished, asked for explanation, Keats replied that the poetical charms of the magnificent rainbow are now destroyed since Newton has reduced it to a prosaic prism. Today, Sir Isaac Newton is honored for that same achievement which the poet deplored.

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Mathematics and Chemistry

• **By Sister Mary Jerome Barry, S.S.J., B.A.,** *(Villanova College)*
DEPARTMENT OF CHEMISTRY, MOUNT SAINT JOSEPH ACADEMY, RUTLAND, VERMONT.

Is an inadequate knowledge of mathematics the greatest single handicap to the progress of chemistry in America?

If so, what can be done about it?

How much mathematics is necessary for the proper understanding of high school chemistry? How much mathematics does the college freshman need? How closely related are physical chemistry and mathematics?

You will be interested in Sister Mary Jerome's opinion on these and related matters.

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Mathematics is to the chemist what an operating instrument is to the surgeon, what the X-ray is to the bone-setter. It is a most valuable tool.

Baddger and Baker of the University of Michigan have stated in the *Journal of Chemical Education:* "Science is best expressed when it is mathematically expressed. Mathematics is a deductive science, while chemistry is essentially an inductive science. A chemist finds it easier to reason from specific facts to general propositions."

A student cannot thoroughly master any course in the theory of chemistry, even in high school, without actually solving problems. The American Chemical Society recommends that no student be accepted in a freshman college chemistry course who has not studied high school algebra and plane geometry, and who does not register for mathematics in his freshman year.

We do not know whether a student understands a theory until he tries to apply it. Problems are our most important aid in discovering this ability. In high school chemistry the student solves problems involving only arithmetic and algebra. To appreciate the full meaning of a chemical equation he must understand the weight to weight ratios therein expressed; the weight to volume and volume to volume ratios; equilibrium constants; and methods of determining molecular weights. And in order to understand the laws governing the effects of temperature and pressure changes on gases, the law of definite proportion, combining weights, and electrochemical laws, the student must resort to mathematics. Students are often found in freshman college chemistry who can recite laws, definitions, and theories perfectly, but who cannot apply the principles to the solution of a very simple problem. Seventy-five per cent of the failures in such classes are due to the fact that freshmen cannot, or do not apply their knowledge of mathematics.

In analytical chemistry the student calculates the strength of solutions, and the per cent of substances present. The analytic data collected may be plotted and mathematically analyzed by means of analytic geometry.

Organic chemistry of an elementary nature requires the least knowledge of mathematics.

Physical chemistry employs all forms of mathematics. A physical chemist is a mathematical chemist. His work is really more mathematics than chemistry. In this course he must employ a knowledge of algebra and trigonometry. Many of the instruments, such as refractometers, he uses are based on principles studied in trigonometry. The study of energy in all forms requires mathematical knowledge.

The industrial chemist must bear in mind that he is expected to show profits, for industry has set up the dollar as its god. He must calculate carefully in order to be economical. Knowing the analysis of a flue gas, for example, the industrial chemist can calculate the per cent of carbon, hydrogen, etc. in the fuel, the rate of flow of the gas, the air used in the combustion, the amount of sensible heat, available heat, etc. He oversees production. His laboratory is a "veritable pencil and writing-pad."

A research chemist now calculates mathematically in a short time, whether or not a certain reaction will take place and the most favorable conditions, such as concentration, temperature, pressure, etc., for carrying out the reaction. Formerly, weeks or months of laboratory work might be required before he knew definitely that the reaction would or would not take place, and the proper conditions for obtaining a favorable yield.

Professor D. P. Nolan, Ph.D., head of the chemistry department, St. Vincent College, Latrobe, Pa., says: "I know of no subject so important to the chemist as mathematics. At St. Vincent we permit no student to graduate in chemistry, who can not offer at least twenty credit hours of college mathematics, of which at least twelve must be above the freshman year."

A high school student who fears mathematics should not think of taking a college course in chemistry with a view to majoring in the field. He must not only "like" mathematics—he must "like it intensely." A college chemistry final examination at St. Vincent contains sufficient problems to bring about the failure of a student who is unable to solve them. This method, commonly employed at the University of Notre Dame is, in principle, used as a means of discouraging unprepared students who wish to pursue the science course.

Chemistry has graduated from the class of descriptive sciences into the class of exact mathematical sciences.

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Some Aspects of Synthetic Rubber

• By Per K. Frolich, Sc.D., *(Massachusetts Institute of Technology)*
ESSO LABORATORIES, STANDARD OIL DEVELOPMENT COMPANY, ELIZABETH, N. J.

More than most persons realize, modern civilization depends upon rubber. It has literally thousands of uses. For some, no acceptable substitute has yet been found. National defense demands enormous and continuing supplies.

Because of the present world situation, it is possible that our supply of crude rubber may be cut off at any moment. In terms of our needs, our reserve supply is meager. Obviously, the production of a cheap and satisfactory synthetic rubber, made from raw materials plentiful in America, would solve our difficulties.

This paper discusses the rubber situation in general and describes in particular one of the newer manufactured rubbers that has a number of advantages over the natural product.

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The fact that rubber has become one of our most valuable and widely used structural materials can be attributed primarily to two of its molecular characteristics. In the first place, Nature's rubber is made up of extremely long, chain-like molecules in which the atoms are so arranged that a product is obtained with a high degree of elasticity. It does not have much mechanical strength, however, until it has been vulcanized. In the second place, the pronounced chemical unsaturation of the rubber molecule makes it possible to link the individual chains together by chemical reaction—i. e., curing or vulcanization—with sulfur, to produce a firm structure of appreciable strength.

According to our present concept, natural rubber, $(C_5H_8)_x$, is a polymer of isoprene, $CH_2{:}CCH_3.CH{:}CH_2$. The problem of developing synthetic rubber-like materials has therefore generally been approached by attempting to reproduce the long-chain, unsaturated molecular structure through polymerization of isoprene, or of other, more readily available, simple conjugated dienes, such as butadiene, C_4H_6, and chloroprene, C_4H_5Cl. More recently it has been shown that a similar result can be obtained by chain polymerization of simple olefins together with only limited amounts of diolefins. In this way the new Butyl rubber has been formed.

Classification

The early efforts of chemists working in this field were directed toward synthesizing a product that would duplicate natural rubber. This work led to the development of such products as Methyl Rubber and Buna. The more recent trend, however, is to synthetic materials closely resembling Nature's product in some respects, while at the same time surpassing it in others. This is clearly illustrated by such products as Neoprene, Buna S, and Perbunan, each one of which excels natural rubber in certain specific properties.

Although many different synthetic diene rubbers have been announced, it would seem that, so far, we are dealing with only a limited number of distinct types. If ability to vulcanize with sulfur is taken as a criterion for a true rubber-like material, the known products may be classified as representing four basic types from the standpoint of the nature of the polymer chain, and also from the standpoint of the characteristic physical and chemical properties.

CLASSIFICATION OF DIENE RUBBERS

Starting Material	*Product*
1. Diolefin.	Natural Rubber (isoprene). Buna (butadiene). Methyl Rubber (dimethylbutadiene). Russian products, SKA, SKB (butadiene).
2. Chloroprene, (possibly also with modifiers).	Neoprene. Sovprene.
3. Diolefins plus modifiers.	Buna S (butadiene + styrene). Perbunan or Buna N (butadeine + acrylonitrile). Possibly other more recently announced products.
4. Olefins plus diolefins.	Butyl Rubber.

Butyl Rubber

The chemical unsaturation of natural rubber, so essential from the standpoint of vulcanization, is also its greatest shortcoming. There is too much of it. Rubber is so highly unsaturated that it remains unstable and chemically reactive even after it has been combined with the small amount of sulfur normally required in the vulcanization process. If we use enough sulfur to overcome this difficulty, we obtain hard rubber or ebonite—which obviously is not the answer for the production of elastic and pliable rubber goods.

In spite of the remarkable progress that has been made in rubber technology, it has not been possible to prevent rubber articles from continuing to combine with chemically reactive agents. The most serious manifestation of this is the well-known deterioration of rubber on aging, due to chemical attack by oxygen from the air. Just as a spare tire loses more and more of its potential road mileage as it grows older, so all our many rubber household articles, including rubber insulated electric wiring, gradually deteriorate until they have to be replaced.

After 3,000,000 flexures or bends natural rubber (left) has failed, while Butyl rubber (right) is still in good condition.

In a research program which has been in progress for nearly ten years, our laboratories have directed their efforts toward conquering this shortcoming of rubber, working independently of any other synthetic rubber development in this country or abroad.

Out of these efforts has come Butyl rubber, which after vulcanization is a product with substantially no residual chemical unsaturation. As a result of this, Butyl rubber is characterized by remarkable stability and durability which for many purposes make it superior to natural rubber and to other synthetics.

Butyl rubber is colorless and free from any odor or taste. Basically, it is a 100 per cent petroleum hydrocarbon product. Being itself a hydrocarbon, just like natural rubber, it definitely does not belong in the class of synthetics that are resistant to swelling in petroleum solvents. Somewhat paradoxically, however, it is more resistant to such simple aromatics as benzol and toluol than even some of the synthetic rubbers now employed in the construction of gasoline dispensing hose.

Butyl rubber may be processed and vulcanized in much the same manner as natural rubber. In general, it vulcanizes somewhat more slowly than natural rubber. It may be more highly loaded with carbon black and other pigments to produce products of a given hardness, and this is an economic advantage.

The tensile strength of Butyl rubber is comparable to that of natural rubber in compounds which do not contain carbon black. As Butyl rubber stretches much more than natural rubber for a given load, its strength per unit cross-sectional area at the point of break is actually much greater. Butyl is readily molded even into articles of intricate design, and its good tear resistance is an aid in removing such products from the hot mold. Its abrasion resistance may be made comparable to that of natural rubber. It is also more resistant to continued flexing, both hot and cold. Indeed, it will flex without cracking at a lower temperature than any other rubber, natural or synthetic. When compounded with carbon black, Butyl is considerably more resistant to sunlight than natural rubber. A further manifestation of Butyl's saturated character is its remarkable resistance to strong mineral acids. As an insulating material it is superior to all other rubbers, and its electrical properties are not adversely affected on immersion in water. It bounces much less than natural rubber at room temperature, but as the temperature is increased to 200° F. its rebound approaches that of natural rubber.

The Esso laboratories are still at work evaluating Butyl for as many of its potential uses as posssible, by such tests as have been devised. Military authorities have been kept currently informed of the development of this new product, and tests were initiated about two years ago to evaluate Butyl for various defense uses.

Preparedness for an Emergency Situation

Our country's current consumption of crude rubber is about 675,000 tons* per year, of which more than 97 per cent comes from the Far East. Under the terms of the cotton exchange agreement with Great Britain, we were to obtain 86,000 tons of crude rubber. About two-thirds of this quantity has now been received.

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*The figure of 600,000 tons frequently quoted in current publications refers to long tons.

Butyl rubber is mixed between steel rolls.

Scholarship and Geology in the United States

• By Arthur R. Barwick, Ph.D., *(New York University)*
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Geology is not one of the "popular" sciences. A number of colleges and universities do not teach it. Others relegate it to the background. Students avoid it. Only two Catholic universities in the United States maintain adequate departments.

Possibly this neglect of a science of great utilitarian and cultural value results, in part, from student ignorance of its subject matter. This in turn may be due to the fact that a fundamental knowledge of several other sciences is needed before the study of geology may be undertaken.

Nevertheless, America has developed many able geologists, but some of them have received little recognition outside their own field. Dr. Barwick calls attention to the activities of some important workers.

This paper was presented before the 1940 Summer Session of the Catholic University of America.

PART I

It may have appeared strange to you that a natural science of such broad applicability as geology does not enjoy a greater place in our educational system. It penetrates practically every phase of human environment and, therefore, has a strong cultural as well as utilitarian value. Possibly student prejudice has no more logical a basis than the inane remark I once heard a student make: "The stuff must be hard because you have to study so many rocks!"

On the contrary, when properly approached, geology has all the allure of a living, palpitating thing: a changing world wherein processes of chemistry and dynamics are being carried on in ever changing kaleidoscopic patterns. Because of these characteristics, it has enlisted the interest of women as well as men wherever it has been given a fair chance, and has enjoyed considerable popularity in such schools as Barnard, Bryn Mawr, Hunter, Mt. Holyoke, and Vassar.

Why, then, does not geology normally enroll the numbers of students that flock to her sister sciences of biology, chemistry, and physics?

The answer is two-fold: first, there is an almost unbelievable ignorance among people who should know better as to what the subject really covers; second, geology is not a basic science in that it requires a fundamental pre-requisite knowledge of other sciences such as biology, chemistry, mathematics, and physics upon the laws of which its inferences are built. For this reason it cannot be taught conveniently in grade or secondary schools where students lack the breadth of training that its understanding requires. Its sister science, geography, has a much greater romantic appeal to the adolescent child; hence, most of our earliest impressions of geological phenomena come from this source. To the teacher of geography a knowledge of geology is indispensable. Yet occasionally we meet statistical automatons who still eke out an existence under the guise of "geographers."

I have found even scientists in other fields who have the impression that geology is a sort of fad for hobbyists from whom wealth has removed the necessity of earning a practical existence! Though that may have been true in the Middle Ages when nature study was somewhat in disrepute, and was often carried on behind locked doors, nothing could be more absurd in the industrial world of today.

Despite volumes of propaganda to the contrary, practically every war in the last two centuries has been fought over the possession of mineral wealth, which is grist to the mills of geology. One of the greatest sources of unrest in Europe is the desire to possess such economic resources as coal and petroleum. The value of these materials, and the uses to which they are put, are greatly enhanced by our knowledge of modern chemistry and physics, but let it be remembered that it requires a geologist, with his understanding of their nature and occurrence, to *find* them in the first place. The method of formation of coal has a lot to do with its future utilization. Some can be used as metallurgical fuels, and some only for the production of heat. Our present understanding of the fundamental nature of coals has made the difference between the great coke-fired smelters of today and the little charcoal furnaces of Colonial Maryland. Upon careful introspection, therefore, we find that geology is the concrete embodiment of pretty nearly all forms of human endeavor, the ubiquitous fountain from which most of the raw products of modern industry are drawn and converted through the marvels of modern physics and chemistry into those things that make our lives more easy and more pleasant to live.

The second reason that geology has not received its just reward in our educational system is the fact that it is not a *basic* science. By this I mean the student of geology must have received a pre-requisite grounding in the fundamentals of biology, chemistry, mathematics, and physics. Few of the students entering our colleges have had training in more than two of these subjects, and the vast majority have been limited to *either* chemistry or physics. While it is obviously true that geologists cannot be accomplished experimentalists in all these fields of science, it is equally true that they must be cognizant of the greater parts of their laws

because the laws of nature are merely the laws of the experimental laboratory applied on a gigantic scale. For example, the biology of fossils gives us the basis for determining past climatological conditions; the chemistry of solution explains, through such laws as the Phase Rule, the nature of the rocks that form the cores of vast mountain systems; the mathematics of hydraulics explains how rivers act and how man can control them; and our growing knowledge of sub-atomic physics affords us a method of determining the age of the earth through the disintegration of uranium and radium.

The background of geology is, therefore, too complicated to be taught unqualifiedly in grade schools, and in secondary schools the sciences of biology, chemistry and physics are still the mainstays. More recently, geography has been winning a well earned place in the sun and it is through this source that our youth get their first glimpse of earth phenomena. It might also be added that this modern rendition of geography is quite a far cry from the old quarto volume of maps of my school days. It is a highly co-ordinated mass of social and economic data. Aside from this there are no direct feeds to geology from the lower levels.

There are very few curricular requirements for geology among upper classmen in colleges. Students are not forced to take it like they are chemistry and physics; they must elect it of their own free will. Is it a wonder, then, that the vacillating types, who really do not know what they want, are prone to follow the line of least resistance and continue on with the sciences they started in high school? I thoroughly believe that a science student entering college should be *made* to taste lightly of those sciences that have not fallen to his lot in his previous education and then be allowed freely to choose those in which his aptitudes are greatest.

It is to those who have never given the vast realm of geology a really careful thought that the remainder of this paper should be most helpful.

Up to the beginning of the 19th Century, geology lay largely in the field of speculative philosophy. The deductive methods of the old Greek philosophers were deeply rooted in the studies of all sciences, and probably none suffered so ruthlessly as the natural science division of which geology is a branch. The idea that all sedimentary rocks were remnants of the Great Flood crystallized under the fiery generalship of Abraham Werner in the late 18th Century, while the alternative theory of plutonism and vulcanism was just as strongly pressed by his contemporary, James Hutton. About this time, also, bitter strife was raging in the realm of organic geology between the Uniformitarians and the Catastrophists. Instead of seeking the truth from both of the opposing schools of thought through careful experimentation, scientists often blindly followed one camp or the other. It was under such inauspicious beginnings that geology first took root in America.

Previous to 1820, the study of geology in the United States was somewhat sketchy and pretty well bogged down in the mire of Wernerianism. Maclure, in 1817, attempted a diluviastic interpretation of the eastern United States upon greatly insufficient data. Cleaveland wrote a book on "mineralogy and geology" which is a monument of ambiguity, a fine example of which is the statement that "anthracite resembles coal from which it, however, materially differs." On the other hand, as early as 1788, such a keen thinker as Benjamin Franklin, in a letter addressed to Abbé Soulavie, expressed ideas distinctly in advance of his time. During this period, also, the boards of trustees of most universities were particularly antagonistic toward natural history in general, and more especially toward geology which was thought to be in disagreement with the ideas of Creation.

The one bright spot for geology was created when President Dwight of Yale College, in 1798, managed to overcome popular objection and to establish at his institution a professorship of chemistry and natural history which was placed under the charge of a young law student, Benjamin Silliman. At the time of selection, he was only twenty-two years of age, and he had had no previous training whatever in the field he was called upon to teach. This was not strange because there was no geology taught in this country at the time. So, for two years he attended the American Philosophical Society at Philadelphia to pick up the trends of American contemporaneous thought along these lines and, after avidly reading all the books that he could obtain, he finally delivered his first lecture on April 4, 1804. He met with great success and students flocked to Yale from all parts of the country. This famous lecturer and teacher, in 1818, founded *The American Journal of Science*, the first publication of its kind in this country. Since that time Yale University has always been outstanding in the annals of American geology and, emblazoned upon its books we find the names of Dana, Marsh, Schuchert, and many other important workers.

The first modern textbook of geology was written by the Englishman, Sir Charles Lyell, in 1830. This was indeed a milestone in geological history. The next year, in our own country, the first State Geological Survey was carried to a successful finish in Massachusetts by Edward Hitchcock. Owing to the rapid westward expansion of the nation and the accelerated industrial growth in the East, the need for raw materials became more and more acute and many other states soon created geological surveys to take stock of their resources. Noteworthy among these are the surveys of New York and Pennsylvania. The first geological survey of the State of New York was authorized in 1836 and completed in 1843. It brought into the spotlight four men: Mather, Emmons, Vanuxem, and Hall. Emmons is most noted for his "Taconic System", which created an international controversy that had repercussions on both sides of the Atlantic for over forty years. Probably the most famous of the group, however, was James Hall who might be called the father of geological correlation in the Western Hemisphere. Hall was about as brilliant and inde-

fatigable as he was hard to get along with, and he turned out the most monumental mass of paleontological literature ever aggregated by an American geologist.[1] The Geological Survey of Pennsylvania is also noteworthy because of the herculean efforts on Appalachian tectonics and coal formation of H. D. Rogers, one of four famous brothers, who was the first American geologist ever to win a chair in a European university.

The Federal Government appointed its first geologist in 1834 in the person of G. W. Featherstonhaugh, an Englishman, who although competent as a geologist, does not seem to have been very popular with contemporary American geologists. After a long hiatus during which little Federal geological work was sponsored other than that undertaken by the Coast and Geodetic Survey, there followed, between the years 1867 and 1879, four territorial explorations. The first of these was the Geological Exploration of the 40th Parallel, from 1867 to 1872, under the direction of Clarence King. This involved a strip about 100 miles wide between the eastern slopes of the Rocky Mountains to the Sierra Nevada Range, between the 104th and 120th meridians. The Geological and Geographical Survey of Territories, under Dr. F. V. Hayden, took place between 1873 and 1878, and covered parts of Colorado, New Mexico, Utah, Wyoming, and Idaho, an area of about 100,000 square miles. The Geographical Survey West of the 100th Meridian, under Captain G. M. Wheeler, covered about 359,000 square miles. The work of the Geographical and Geological Survey of the Rocky Mountain Region, under Major J. W. Powell, covered an area of about 67,000 square miles, in Wyoming, Utah, and Arizona.

The United States Geological Survey was created by an Act of Congress on March 3, 1879.[2] Its first Director was Clarence King who was succeeded, in turn, by Major J. W. Powell, C. D. Walcott, G. O. Smith, and finally by the present incumbent, W. C. Mendenhall. Its work has been both meritorious and fruitful. It has studied and encouraged the exploitation of the natural resources of vast tracts of hitherto unexplored territory in the West, in Alaska, and in other possessions of the nation, thereby adding greatly to the wealth of our country. It is upon the development of these resources that the United States has forged ahead to a major world power in the last half century.

Another phase of the work of the United States Geological Survey is that of the Division of Hydrography which provides daily data on the flow and behavior of all of the important rivers of the United States. These data make possible the development of great dams such as that at Boulder Canyon; extensive irrigation and reclamation projects; and the prevention and amelioration of floods. Lastly, the work of the United States Geological Survey has encouraged the nation to set aside vast forest reserves and national parks as part of the public domain so that these areas of scenic grandeur may forever be freely available to the citizens of our country.

There are many associations of learning in the United States that are interested in the elucidation and development of the science of geology. Among these are the various academies of science in the major cities; the American Association for the Advancement of Science; the American Institute of Mining and Metallurgical Engineers; and the Geological Society of America; and a host of local geological, mineralogical, and paleontological societies of both a public nature or in connection with our larger universities. Of all these, the Geological Society of America is the most outstanding. It occupies the key position as the international center of geological thought and compares favorably with the famous old geological societies of Europe. The Geological Society of America was developed in 1888 as an offshoot of the American Association for the Advancement of Science. Its full membership is subject to election by ballot, which is possible only after the applicant's work has been carefully scrutinized and evaluated. Fellowship in the Society, however, is open to all qualified workers in the field of geology. It has affiliated branches, such as the Mineralogical Society of America, the Paleontological Society, etc.

The writer recently made a study of geological curricula in several hundred of our leading United States universities. Several very interesting facts were brought to light. These will be discussed, with statistical data, at a later date. A few broad points, however may be presented in our present discussion. Aside from the basic studies of general geology and mineralogy, which are practically universal wherever departments of geology exist, it was readily apparent that paleontology and economic geology led as advanced fields of specialization. Structural geology, stratigraphy, and field work constituted the next important field of endeavor; and after these trailed the various branches of petrology, petrography, optical mineralogy, etc. In areas where they were abundant, great stress was laid upon the study of oil, coal, etc. On the other hand, engineering geology, and political and commercial geology were poorly represented. The reason for the latter was probably the absorption by geography, but that could hardly have affected the former. Another rather interesting discovery was the almost entire lack of geological training in Catholic institutions. The only two that carried adequate departments of geology were the Catholic University of America and St. Louis University. In the specific field of seismology, however, many of the Jesuit institutions were outstanding. This indicates that in all the other leading fields of geology, the majority of the eminent Catholic geologists received their training in non-Catholic institutions of learning. I feel that this is something for the Catholic mind to ponder over regarding such an important branch of science. ●

The concluding part of this paper will appear in our December number.

Balancing Oxidation-Reduction Equations

• **By Sister Mary Martinette, B.V.M., M.S.,** *(St. Louis University)*
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Writing equations frequently becomes a stumbling block to students when oxidation and reduction are involved. But the balancing of such equations is really not difficult if the students understand even one of several possible procedures.

Sister Martinette, who has studied the commonly used methods, here points out the one she thinks most useful.

Do you agree with her selection?

This paper was read at a recent meeting of the Chicago Catholic Science Teachers Association.

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Our purpose in asking students to balance equations should be to teach chemical principles.

Most teachers find it rather easy to explain the procedure of balancing to the satisfaction of students, until they attempt to present oxidation-reduction equations; then countless difficulties, real and imaginary, arise.

In the literature we find several suggestions for help and improvement in teaching this material. The avenues of approach are numerous, although the actual scientific methods seem to be limited to four. Listing them in their order of apparent importance they are:

1. **The Ion-Electron Method.**
2. **The Valence Change Method.**
3. **"A Unique Method."**
4. **The Algebraic Method.**

The ion-electron method is undoubtedly the most scientific, revealing more of the actual reaction to the student than any other method of balancing redox equations. This should be borne in mind as we compare the several methods.

Since the algebraic method seems to be the least valuable it will not be explained here. It has been well described by Horace G. Deming of the University of Nebraska in the *Journal of Chemical Education*.[1] Professor Deming makes use of determinants in his solution. We list this method as the least important because the average student, the one who will need a great deal of "teaching" of this material, is not of a mathematical turn of mind.

A Unique Method

The "Unique Method" is of less value for the same reason, but it is less complicated and has a definite "interest arousing" value. Applying it to the common redox equation

$$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$$

let the unknown coefficients be a, b, c, d and e, reading from left to right. Working out partial equations—

equation 1 for Cu, $a = c$
equation 2 for H, $b = 2e$
equation 3 for N, $b = 2c + d$
equation 4 for O, $3b = 6c + d + e$

Now if we obtain all values in terms of a we can give a a definite value and solve for the remaining letters. If

$$c = a$$
$$b = 2a + d \text{ (from equation 3)}$$
$$\text{and } d = b - 2a \text{ (from equation 3)}$$

Substituting in equation 4:

$$3b = 6a + b - 2a + e$$
$$2b = 6a - 2a + e$$
$$2b = 4a + e$$
$$b = \frac{4a + e}{2}$$

Substituting in equation 2:

$$2e = \frac{4a + e}{2}$$
$$4e = 4a + e$$
$$3e = 4a$$
$$e = 4/3\,a$$

Substituting the value for e in the equation b:

$$b = \frac{4a + 4/3\,a}{2} = 8/3\,a$$

Substituting in equation 3:

$$8/3\,a = 2a + d$$
$$-d = 2a - 8/3\,a$$
$$d = 2/3\,a$$

If we let $a = 1$, this gives us the following values:

$a = 1$ $c = 1$ $e = 4/3$
$b = 8/3$ $d = 2/3$

and our equation reads:

$$Cu + 8/3\,HNO_3 \longrightarrow Cu(NO_3)_2 + 2/3\,NO + 4/3\,H_2O$$

Multiplying through by 3, we have:

$$3\,Cu + 8\,HNO_3 \longrightarrow 3\,Cu(NO_3)_2 + 2\,NO + 4\,H_2O$$

This method was worked out by a student in a freshman chemistry course at Hiram College, Ohio[2].

Valence Change Method

The valence-change method is of much older origin. It first appeared in the literature in 1880.[3] Taught after the concept of valence has been learned, it depends on the student's understanding of a few of the fundamentals, such as

1. The sum of the valences of all the atoms in a compound is zero.
2. The valence of H is always taken as positive 1.

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Notes on Catholic Physiographers

• By Sister M. Dafrose, O.P., Ph.D., *(Fordham University)*
BISHOP McDONNELL MEMORIAL HIGH SCHOOL, BROOKLYN, NEW YORK.

In this paper Sister Dafrose presents much useful information in capsule form about the most famous Catholic physiographers of all time.

Here you will find material that will aid in developing a background in the history of science. Perhaps you will be stimulated to learn more about some of the scientists to whom Sister Dafrose is able to give only brief mention because of lack of space.

A paper dealing in a similar way with Catholic chemists and their accomplishments, written by the same author, appeared in THE SCIENCE COUNSELOR, *Volume V, No. 4.*

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EARTH—THE HOME OF MAN

Agricola, George B. (1494-1555), is the "Father of Mineralogy" whose work on metallurgy (*De Re Metallica*, 1546) is the most important pioneer work on the subject.

Deville, Charles St. Claire (1809-1857), formulated a new theory to explain volcanic phenomena. He made important meteorological researches.

Fuchs, Johann N. Von (1774-1856), is renowned for his analysis of minerals. He discovered a process for producing a soluble glass which is emplcyed in stereochromy, a type of fresco painting. A certain kind of muscovite is known as fuchsite in his honor.

Hagen, J. G., S. J., was born in Austria in 1847. He was professor of Mathematics at Georgetown University from 1880-1888, when he was appointed director of the seismological observatory at the University. Later he was appointed director of the Vatican Observatory. Much of his research was devoted to the variable stars and to nebulae and cosmic clouds. He was the author of *Atlas stellarum variabilium*.

Hautefeuille, Jean De (1647-1724), French priest-scientist, invented an instrument called a thalassameter for registering the tides. The value of this discovery was attested to by tributes from the French Academy of Sciences.

Hauy, Rene J. (1743-1822), founded the science of crystallography, formulated the geometrical law of crystallization, and drew up a system of classification of minerals.

Hengler, Lawrence (1806-1858), was the priest-inventor of the horizontal pendulum used in seismographs.

Mallard, Ernest Francois (1833-1894), was one of the pioneers in crystallography. He was particularly famed for his investigations on the physical properties of crystals. He did valuable work on isomorphism and crystallographical instruments.

Montanari, G. (1632-1687), an Italian astronomer, was Professor at the Universities of Bologna and Padua. He is said to have discovered the method of determining the height of mountains by means of the barometer. He wrote many learned treatises on astronomy.

Odenbach, F. L. (d. 1933), an American Jesuit scientist, was born in Rochester, N. Y. and died March 15, 1933, in Cleveland, Ohio. He is known as the "Father of American seismology." He invented the electric seismograph and the ceraunograph. He was professor of science at John Carroll University, Cleveland, Ohio, (1893-1933), and director of the seismological observatory. He was an authority on intermittent springs and earthquakes.

Tondorf, Francis A., S.J. (1879-1929), was born in Boston July 17, 1879 and died at Georgetown University November 29, 1929. His life was an inspiring record of untiring labor and devotion to scientific studies. His work in seismology stands out as a landmark of scientific progress in this country. The great Japanese earthquake in 1923 brought him international renown. Father Tondorf wired to the Associated Press many hours before the catastrophe was known here in the U. S. that there had been strong earth tremors about 6,000 miles from Washington, and that Japan was probably the center of the zone.

Besides checking upon numerous seismic disturbances recorded daily on the machines at Georgetown University, Father Tondorf issued a monthly bulletin on earthquakes to all observatories in the world. A short time before his death, when earthquake shocks were felt throughout New England and New York (November 18), Father Tondorf reported to the U. S. Coast and Geodetic Survey that the disturbance had occurred in the Atlantic Ocean, somewhere southeast off the Newfoundland Coast. Later reports of cable ships repairing broken lines at the scene of disturbance again proved the accuracy of Father Tondorf's statement.

Monsignor Ryan of the Catholic University of Washington said: "He was a wonderful example of what a Catholic scientist ought to be." Dr. W. H. Wilmer of John Hopkins University said: "He was a myriad-minded man, and his scientific achievements could be equalled only by his greatness of heart and beauty of character."

EARTH SURVEY AND MAP MAKING

Saint Albertus Magnus, O. P. (1193-1281), the "Universal Doctor" of the Middle Ages, opened up the study of physiography to contemporary scholars. He gave proofs of the sphericity of the earth and laid the foundations of comparative geography by his exposition of Aristotle.

Behaim, Martin (1459-1507), made the oldest geographical globe in existence. (*Ca.* 1492).

Clavius, Claudius, S. J., (b. 1388), made the first map of northwest Europe. This map exercised a great influence on the development of cartography.

D'Abbadie, Antoine T. (1810-1897), made invaluable contributions to the geographical knowledge of Abyssinia. He drew up a map of the southern province of that country. He distinguished himself as a topographist and improved earth measuring instruments.

De Deza, Bishop Diego, O.P., was for some years professor of astronomy at the University of Salamanca. He was a follower of the teaching of Albertus Magnus concerning the sphericity of the earth, and one of the most influential personages in obtaining assistance for Columbus. Remesal says: "In order to gain to his views the monarchs of Castile, Ferdinand and Isabella, Columbus came to Salamanca with the purpose of presenting his reasons to the masters of astrology and cosmography who taught these matters at the University. He began by proposing to them his theories and arguments, but met with no attention and found no welcome save among the Dominican religious of San Esteban. The reason for this was that they taught in this convent the sphericity of the earth and all the astronomical arts in addition to the arts and theology. Astronomers and mathematicians held their meetings there. Columbus proposed his conclusions and defended them. Thanks to the authority of the Dominican religious, he gained to his opinion the most learned men of the schools, especially Fray Diego de Deza. On account of the influence of the latter both among scholars and with the sovereigns, Columbus ascribes to his assistance the discovery of the Indies." *(Historia de Chiapa y Gautemala Bk.* 2, Chap. 7).

De La Cosa, Juan (1460-1510), accompanied Columbus, in the office of cartographer, on his second voyage to America, and drew up a celebrated world chart which is considered the first map of America.

Mercator, Gerard (1512-1594), a Flemish geographer, is chiefly known for his method of geographical projection. He published the first hydrographic map and drew numerous maps and charts in the cylindrical type of map projection.

Olaus Magnus, Bishop (1490-1558), was one of the most distinguished geographers of the Renaissance.

Ortelius, Abraham (1527-1598), was a geographer and cartographer. In 1570 he published the first great modern atlas and in 1587 a dictionary of old geography still useful today.

Peuerbach, George Von (1423-1461), was an Austrian scientist. His principal work was an attempt to reconcile opposing theories of the universe. This attempt, enormously successful in clearing up the difficulties that were impeding the progress of astronomical science, laid the foundations for the Copernican system.

Piazzi, Guiseppe (1746-1826), a Theatine, discovered the first planetoid, Ceres, (1801) and was the author of a star catalog including about 7,000 fixed stars.

Polo, Marco (1251-1324), was one of the greatest travelers of all times. The remarkable account of his travels is a classic in geography.

Resphigi, Lorenzo (1824-1889), was distinguished for spectroscopic research. He discovered three comets. He made charts and catalogues of his discoveries, giving permanence to the results of his research.

Santini, Giovanni (1787-1877), was an Italian astronomer, appointed by the Italian government director of the Observatory at Padua. He made it renowned for its equipment and for the thoroughness of its work. He acquired fame by his planetary researches. He plotted the path of several comets and wrote numerous dissertations on astronomic and geodetic subjects.

Tieffentaller, Joseph, S. J. (1710-1785), was a noted geographer who wrote *Descriptio Indiae,* illustrated by various maps.

Waldseemuller, Martin (1475-1522), drew up the first modern atlas of the world, a Latinized edition of Ptolemy's geography. He added twenty maps, and first used the name America on his world map (1507).

GEOLOGY—STORIES IN STONES

Barrande, Joachim (1799-1833), is famed for his great work on the Silurian system in Bohemia, and for his scientific researches on fossilization.

Camboue, Paul, S. J. (1849-1909), was a French geologist who made known much of the geological structure of French Madagascar.

Daubree, Gabriel (1814-1896), was a French geologist who did distinguished work on Scandinavian metalliferous strata, on metamorphism and thermal waters.

Dumont, Andre (1809-1859), drew up a masterly geological map of Belgium. He did renowned research work on the stratigraphy of European geological formations and devised a nomenclature for certain divisions of the Cretaceous and Tertiary Ages.

Halloy, Jean B. (1783-1875), a Belgian scientist, is one of the pioneers of modern geology. His geological investigations extended throughout France, parts of Italy, the Rhineland and Belgium. His geological map of France and the neighboring territories provided the basis of recent regional studies. His investigations in the carboniferous districts of Belgium and the Rhine provinces and in the tertiary deposits of the Paris basin are especially noteworthy.

Hilgard, E. W. (1833-1916), was born in Bavaria and died in California. He was the chief chemist in the Smithsonian Institute and professor of geology in the Universities of Michigan and California. His study of soils made him an expert on soils in humid and arid regions, alkali soils, and their reclamation. As a result of the work of Hilgard the "Great American Desert" was, and continues to be, transformed into fertile land.

Lapparent, Auguste De (1839-1908), was professor of geology and mineralogy at the Catholic Institute, Paris. In 1868 he did outstanding work in the dolomite district of the Tyrol. His *Traité de Geologie* is encypedic, an indispensable work of reference and of sug-

gestive guidance to every student of modern geology. A feature particularly notable was the introduction into the text of numerous maps to illustrate the geographic features of different regions in successive geological periods.

Lossen, C. A. (1841-1893), German petrologist and mineralogist published more than one hundred treatises on geology (1867-1891) which were highly valued by his fellow scientists. Of great importance are his papers on the contact and dynamo-metamorphosis of minerals. The mineral lossenite is named in his honor. His petrolographic studies of the Hartz Mountains—the labor of a life time—are greatly valued.

Schafhaütl, Karl Frederick Von (1803-1890), was a pioneer in geological knowledge of the Bavarian Alps. He first found nitrogen in iron ore, and initiated the production of artificial quartz crystals.

Steno, Nicolaus (1638-1687), is the "Father of Geology," world renowned for his geological discoveries. He gave the first explanation, accepted by scientists, of petrifactions in the earth.

Termier, Pierre (1866-1937), French geologist, was the director of the geological chart of France and a lecturer in the School of Mines, Paris. He was also a research geological voyager who enriched the science of geology by numerous contributions.

Waagen, Wilhelm (1841-1906), did noted research work on the fossilization of the German Jura Mountains. He was the first scientist to apply the theory of transformism to paleontology.

THE EARTH, A MEMBER OF THE SOLAR SYSTEM

Boscovich, A. J., Ruggiero (1711-1787), Italian astronomer, published astronomical dissertations on sun spots and the transits of Mercury. He invented a micrometer, still in use, which requires no artificial illumination of the field of the telescope.

Cassini, Giovanni D. (1625-1712), determined the periods of rotation of Jupiter, Venus and Mars. He formulated a theory of comet motion, discovered four satellites of Saturn and was the first Director of the Observatory of Paris.

Copernicus, Nicholas (1473-1543), was a Prussian Dominican who originated the Copernican System (heliocentric planetary theory) which superseded the Ptolemaic System, proving that the earth and planets revolved about the sun.

Crommelin, Andrew (1865-), as assistant of the Royal Observatory, Greenwich (1891-1927) made valuable investigations on eclipses, and in conjunction with P. H. Cowell, on Halley's Comet.

Cusa, Nicolaus De (1400-1464), was a German Cardinal. His astronomical views are scattered throughout his philosophical writings. He maintained that the earth is a star like other stars, is not the centre of the universe, is not at rest, nor are its poles fixed, that the celestial bodies are not strictly spherical, nor are their orbits circular. Had Copernicus been aware of these assertions he would probably have been greatly encouraged to publish his own monumental work.

De Vico, Francis, S. J. (1805-1848), directed the Observatory at Rome and made valuable observations of comets, six of which he discovered. He calculated the time of the return of Halley's comet, which was looked for in 1835, and was the first to see it on August fifth of that year. He also published several treatises on the planets Saturn and Venus.

Faye, Herve Auguste (1814-1902), was a French astronomer. In 1843, he discovered the comet bearing his name, improved the method of astronomical measurements, invented the zenithal collimator and applied photography and electricity to astronomy.

Foucault, J. B. Leon (1819-1868), a French scientist, demonstrated the rotary motion of the earth by means of a freely suspended pendulum. This was but one of his many scientific experiments and contributions to scientific progress.

Galilei, Galileo (1564-1642), did distinguished telescopic work. He discovered the gibbous phase of the moon, four satellites of Jupiter and phases of Venus. He also did research on sunspots and made improvements in the telescope. By his telescopic observations he produced telling evidence to corroborate the Copernican hypothesis.

Heis, Edward (1806-1872), drew up a chart of naked-eye stars visible in Central Europe (5421 stars were indicated and the first authentic map of the Milky Way was included). He was the first astronomer to ascertain the point of departure of meteors.

Lamont, Johann Von (1805-1879), the director of the Munich Observatory, determined the mass of Uranus.

Lemaitre, Abbe Georges (1895-), French priest-scientist, is one of the leading mathematical physicists of our time. He is Professor in the University of Louvain. Recently, he has been in America. His theory aims to show mathematically that the universe is expanding like a colossal soap bubble. The theory propounded by Lemaitre tries to reconcile two diametrically opposing conceptions of the universe:

1. Einstein's theory which predicated a universe which was curved and so static that it would collapse if it were disturbed.
2. de Sitter's, which theorized an empty but expansive universe.

Perry, Stephen Joseph, S. J. (1833-1889), director of Stonyhurst Observatory, studied, in particular, solar spots and faculae. He was sent by the British Government on numerous scientific expeditinos, observing the transits of Venus at Kerguelen (1874), Madagascar (1882), and the solar eclipse at the Isles de Salut (1889).

Riccioli, John Baptist (1597-1671), Italian, is the astronomer who introduced the lunar nomenclature, still used today.

Scheiner, Christopher, S. J. (1575-1650), was a Jesuit astronomer. He invented the pantograph or copying in-

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Physical Science for General Education. *Part III*

• **By Robert H. Carleton**
CHAIRMAN, SCIENCE DEPARTMENT, SENIOR AND JUNIOR HIGH SCHOOLS, SUMMIT, N. J.

This, the concluding paper of a series, consists of a Comprehensive Test on a special teaching unit that has been outlined and discussed in previous issues.

We print the Test in full as an example of good examination practice in the science field.

Science teachers who study it will obtain useful hints that will enliven their own work.

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COMPREHENSIVE UNIT TEST
FIRE, FUEL AND HEAT

PART I. RECALL AND APPLICATION OF SPECIFIC KNOWLEDGES

A. Directions. Following are several partial statements each followed by several possible answers. Select the most appropriate completion answer and write its number in the space provided.

1.____ If a clean, gas stove burner gives a yellow flame, the adjustment needed is probably (1) a decreased gas supply; (2) an increased air supply; (3) a new mixing valve; (4) a gas filter; (5) a new kind of fuel gas.

2.____ Heat from steam radiators is distributed throughout a room chiefly by (1) conduction; (2) convection; (3) radiation; (4) diffusion.

3.____ Matches as devices for reaching the kindling temperature of fuels have been in use for about (1) 1,000 years; (2) 500 years; (3) 100 years; (4) as long as fire has been known.

4.____ The fuel gas supplied to consumers in this community is (1) coal gas; (2) water gas; (3) producer gas; (4) natural gas; (5) acetylene.

5.____ Man's understanding of the true nature of fire and burning is about (1) 1,000 years old; (2) 5,000 years old; (3) 590 years old; (4) 160 years old; (5) as old as the use of fire itself.

6.____ In case of an electrical fire (in electrical machinery or around electrical wires), it is best to (1) extinguish it with water; (2) use a soda-acid extinguisher; (3) use a carbon tetrachloride fire extinguisher on it; (4) do nothing until firemen arrive.

7.____ A grease fire in the kitchen (as in a broiler) can be extinguished by throwing onto it some (1) baking soda; (2) water; (3) sulfuric acid; (4) household ammonia water.

8.____ According to the U. S. Department of Commerce, about 50% of the heat lost from the average dwelling in winter passes out through (1) the chimney; (2) cracks around doors and windows; (3) open doors and windows; (4) the walls and roof; (5) the basement.

9.____ Pure oxygen is manufactured for commercial use from (1) potassium chlorate; (2) liquid air; (3) mercuric oxide; (4) coal tar.

10.____ In calling the fire department to a fire by means of the telephone, one must be sure to (1) pay for the call; (2) tell the firemen what apparatus to bring; (3) give the exact location of the fire; (4) try to extinguish the fire himself before calling.

11.____ Good insulation of gas or electric range ovens is important in saving fuel and also in (1) making the kitchen more comfortable; (2) preventing the formation of carbon monoxide; (3) reducing the danger of oven fires.

12.____ To make a house cooler during hot weather, (1) provide an electric fan; (2) open the refrigerator door; (3) insulate the walls and roof; (4) open the windows during the day and close them at night.

13.____ If you must clean garments at home, the best cleaning fluid to use is (1) ethyl gasoline; (2) regular gasoline; (3) naphtha; (4) carbon tetrachloride; (5) benzene.

14.____ More persons are suffocated than burned to death during fires. In a smoke-filled room, the purest air is found (1) near the floor; (2) near the ceiling; (3) near the windows.

15.____ One source of reliable facts and information on a variety of topics pertaining to fire, fuels, and heat is (1) your neighborhood coal and fuel oil dealer; (2) the Superintendent of Documents, Washington, D. C.; (3) your fire insurance company.

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B. Directions. Mark with a plus sign the items which are consistent with, or give a correct idea about, the introductory words; mark with a zero the items which are inconsistent or give a false idea.

In order to have ordinary burning

16.____ a combustible material is necessary;
17.____ a good supply of carbon dioxide must be provided;
18.____ the kindling temperature must be reached;
19.____ an adequate supply of oxygen is required.

Under various conditions of burning, products formed may include

20.____ carbon dioxide;
21.____ oxygen;
22.____ smoke;
23.____ water vapor;
24.____ carbon monoxide.

To provide an adequate supply of gasoline in the U. S., we

25.____ treat petroleum by fractional distillation;
26.____ treat coal by destructive distillation;
27.____ "crack" kerosene and heavier oils;
28.____ condense and collect the vapors present in natural gas;
29.____ may have to manufacture gasoline from coal within forty years.

The insulation of a dwelling

30.____ will certainly bring about a reduction in fuel expenditures;
31.____ will certainly "pay for itself" in about three years;

32.____ cannot be nearly as effective when applied to existing houses as when applied to new houses as they are built;

33.____ provides numerous benefits that do not show up in the reduced fuel bill.

If one desires to prevent heat losses, under certain conditions one could

34.____ provide "dead air" spaces;

35.____ use a poor conductor of heat;

36.____ paint the surface with "dead black" paint;

37.____ pack the space with mineral wool or asbestos.

When a pan of water has once reached the boiling point and the flame is permitted to continue licking up around the utensil

38.____ increased production of carbon monoxide is likely to result;

39.____ the temperature of the water rises above its boiling point;

40.____ the water will boil away faster than if the flame is lowered;

41.____ much gas is wasted if you are boiling potatoes.

Gas appliances and accessories

42.____ should be given no consideration of purchase if they do not bear the seal of the American Gas Association;

43.____ cause much discomfort and ill health through the production of carbon monoxide by improper functioning or use;

44.____ should be adjusted by a trial and error process on the part of the user;

45.____ may be inspected and adjusted without extra charge by the more progressive gas companies.

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C. **Directions.** Following are two groups of items. For each item in the second group, select one, two, three, or whatever number of items needed from the first group to answer the question. Write the correct numbers in the spacees for answers.

1. Carbon tetrachloride	7. Water gas
2. Coal tar	8. Charcoal
3. Ethyl alcohol	9. Coal Gas
4. Coke	10. Phenol or carbolic acid
5. Wood alcohol	11. Acetylene
6. Gasoline	12. Anthracite coal

46.____ Three products obtained by the destructive distillation of soft coal.

47.____ Three liquid fuels.

48.____ Obtained by the destructive distillation of wood.

49.____ Prepared by fermentation of grain.

50.____ Source of several materials used in the manufacture of drugs, dyes, medicines, flavorings, and explosives.

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PART II. UNDERSTANDING AND APPLICATION OF BASIC SCIENCE PRINCIPLES

Directions. Following are two groups of items, the first a list of science principles relating to heat, the second a list of things that happen which can be explained in terms of these principles. For each statement in the second group, select the one principle from the first group which provides the best explanation or reason and write its number in the space provided.

1. Heat causes solids, liquids, and gases to expand, thereby decreasing their density.

2. Heat causes convection currents in liquids and gases.

3. Solids transmit heat by conduction.

4. Heat passes through a vacuum only by radiation.

5. Heat always tends to flow from regions of high temperature to regions of low temperature.

6. Radiant heat can be reflected and focused.

7. Dark rough surfaces are good absorbers and good radiators of heat.

8. Bright smooth surfaces, particularly if light-colored, are poor absorbers and poor radiators of heat.

9. Materials do not burn at temperatures below their kindling points.

10. Air is a poor conductor of heat.

11. Evaporation is a cooling process.

51.____ A fire produces its own draft.

52.____ Rock wool, spun glass, and puffed mica are effective conservers of heat.

53.____ Some types of insulating materials have a surface coating of thin aluminum foil.

54.____ The liquid in an ordinary thermometer rises when the temperature increases.

55.____ No circulating pump is needed in a hot water system.

56.____ The walls of a thermos bottle are silvered.

57.____ Water can be boiled in a paper bag.

58.____ Woolen fabrics are noted for their warmth.

59.____ Double windows on a house are effective in conserving heat.

60.____ Small electric heaters are usually fitted with polished, parabolic backs.

61.____ The handle of an all-metal skillet becomes hot when the pan of the skillet is heated.

62.____ Spaces are left between the sections of railroad tracks, highways, and bridges.

63.____ A bi-metal thermostat "makes or breaks" an electrical circuit as the temperature changes.

64.____ A pneumatic tire is more likely to blow out in summer than in winter.

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PART III. UNDERSTANDING AND APPLICATION OF SCIENTIFIC METHODS AND ATTITUDES

A. In an experiment dealing with the evaporation of water, equal quantities of water were put into each of two similar aluminum tea kettles. One vessel was heated over a burner for 15 minutes, and the other was heated similarly for 10 minutes. The quantity of water in each vessel was then measured. Mark the statements plus or zero to indicate whether they are true or false.

66.____ The experimenter was attempting to determine the effect of aluminum on the rate of evaporation of water.

67.____ The problem was being studied by the trial and error method.

68.____ The variable factor in the experiment was the time of heating.

69.____ If there was any difference in the quantities of water after the experiment, the cause was the amount of water used.

70.____ The results of the experiment would not be influenced by the hopes, expectations, and hypotheses of the experimenter.

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NEW BOOKS

Photograph by Robert Turiff Hance

The Earth and Its Resources

• *By* V. C. FINCH, G. T. TREWARTHA and M. H. SHEARER. McGraw-Hill Book Company, Inc., New York. 1941. x + 634 pp. $2.40.

This is a well made, copiously illustrated, modern physical geography, as interesting in contents as it is attractive in format. The authors are experienced teachers who have taken pains not to write over the heads of the readers for whom the book is intended. Pupils will be grateful. Teachers, too, will appreciate the many instructional helps that are provided. Each chapter concludes with a summary, questions, suggested activities, topics for class report, and a list of references.

With a book like this an alert teacher can make physical geography live, especially just now when the influence of natural resources upon world economic, social and political problems is so clearly apparent.

H.C.M.

Materials of Industry

• *By* SAMUEL F. MERSEREAU, Brooklyn Technical High School. McGraw-Hill Book Company, Inc., New York. 1941. Revised Edition. xxiv + 578 pp. $2.00.

Although it is intended especially for use in technical high schools and in industrial and vocational schools, all high school boys will enjoy this book. It deals not only with the production and properties of the common raw materials of industry but also with their transportation and processing.

Grouped under forest products, non-metallic minerals, iron and steel, non-ferrous metals, and miscellaneous headings, are to be found discussions of some 48 topics including such diverse materials and processes as lumbering, wood distillation, tanning, petroleum, asbestos, cement, glass, coal, smelting, steel, aluminum, copper, rubber, plastics and paint.

This book will be a worthwhile addition to any high school library. *J.F.M.*

Science On the March

•*By* J. A. CLARK, F. L. FITZPATRICK, and EDITH L. SMITH. Houghton Mifflin Company, Boston. 1941. xxvi + 572 pp. $1.72.

This is another textbook in general science for high schools, and a most attractive one. It is proof that beginning science can be made not only thought-provoking and informative, but alluring as well.

The book is planned in the form of problems each of which is to be completed in one period of work. Four problems are grouped to form a chapter, and the chapters are arranged in ten units which deal with air, water, food, sun energy, health, the universe, weather, natural resources, communication and transportation, and reproduction. Pupils are encouraged to think out and work out their own solutions to the problems.

Those who study this textbook should develop enquiring minds. General Science, a study which too often suffers from administrative neglect, will be benefited by the publication of this well planned and well made book. *H.C.M.*

Material Facilities Needed in the Training of Intermediate Grade Teachers in Science

• *By* HARRY A. CUNNINGHAM, Ph.D. Bureau of Publications, Teachers College, Columbia University. New York. 1940. vii + 162. $2.00.

This is a painstakingly detailed and documented consideration of the material facilities, rooms, furnishings, equipment, and supplies that are desirable or necessary for the training of intermediate grade teachers in science.

The study is objective. Data were obtained by curriculum analysis, by studying the facilities actually in use in 17 teachers colleges, and by examining those in use in 25 elementary schools. Related information was derived from several other sources. Eleven appendices supply interesting data.

Dr. Cunningham draws a number of conclusions and makes certain recommendations that will be useful to all those who direct the training of teachers of science.

H.C.M.

Modern-Life Chemistry

• *By* F. O. KRUH, ROBERT H. CARLETON, and F. F. CARPENTER. J. B. Lippincott Company, Chicago. 1941. xxv + 774 pp. $1.80.

The authors of this important textbook state their belief that chemistry is not to be taught merely for the sake of chemistry but for the sake of the learner as well, and that high school chemistry should function so as to modify human behavior in a desirable way, both in its individual and social aspects. In this new edition of their highly regarded book the authors have done a good job of translating their belief into action.

Subject matter has been selected with unusual care. The first five units give as good an exposition of fundamental chemical theories as is found in any elementary book we know. The remaining six units deal with chemical facts. The material is well adapted to the capacities of high school pupils. Motivation is not neglected. The usual teaching aids are provided.

This is not a book for the playboy student nor for the teacher who does not take his teaching and his chemistry seriously. It doesn't scratch; it digs beneath the surface. If you want that kind of book, here it is.

Our readers will be interested to learn that one of the authors of this book is the writer of the series of articles on *Physical Science for General Education* that is completed in this number of the *Science Counselor.*
H.C.M.

Plane Facts for Airplane and Engine Mechanics

• *By* BERT A. KUTANOFF. Military Book Company, New York. 1941. 241 pp. $1.75.

To all those who are interested in engines, airplanes, and aviation—and what young man isn't?—this book should be made available. The workers for whom it is designed will find it valuable. So will aviators and handy-man workers around engines and airplanes. The material it contains is practical. It has been boiled down to its essentials, and is presented in a form that is easy to take. Many drawings and photographs illustrate the text. The questions and answers included in each chapter should be an aid to self instruction.
J.F.M.

An Introduction to Biology

• *By* J. C. CROSS, The Texas College of Arts and Industries. The C. V. Mosby Company, St. Louis, 1941. x + 507. $1.90.

Three hundred and forty-one pages of this book are devoted to the descriptions of types of plants and animals. These brevities include considerable lore that is interesting as general information. The remaining 166 pages deal with the fundamental organ systems of the principal biological representatives. At first reading this book gives the impression of being styled after the manner of books written years ago. Second perusal suggests its very possible usefulness in survey courses and in teachers colleges where broad and general rather than specialized information is needed. *R.T.H.*

Fundamentals of Plant Science

• *By* M. ELLEN O'HANLON, Rosary College. F. S. Crofts & Co., New York, 1941. x + 448. $4.25.

Here is another "Botany" excellently conceived and presented in typical textbook style. The material the instructor wants to impress upon his students concerning plants and the general aspects of life will be found here impressively spotlighted. Under adequate guidance, the substance and the spirit of botany, as developed in this book, should give those who use it as their first and last contact with the subject a satisfactory cultural insight. The suggestions for consideration and reading, beyond the requirements of the course, that end each chapter are much more intriguing and consequently much more likely to achieve the desired results than are the pedantically phrased questions that are commonly used for this purpose. The illustrations, largely prepared by the Art Department of Rosary College, are many and helpful. The pencil sketches of historic biologists are copies of the less well known portraits and are well done. In several cases they lose effectiveness through being much lighter in shade than is the printed text that surrounds them. They deserve a page to themselves.

In the discussion of organic evolution the very necessary but all too rare distinction is made between the evidence of the kinship of living things and the attempts that have been made to explain how these relationships have come about. After reading many textbook summaries of this part of biology I am beginning to wonder whether the average writer (including myself) on biological subjects should attempt an exposition of this subtle body of data. Certainly in the present text, the material on organic evolution, well as it is handled, will be over the heads of the average college freshman for whom it is intended. Genetics is well, although almost too thoroughly, done for good teaching results. Mendel's original discoveries and conclusions are brought up to date with satisfactory references to the modern work of the past thirty years. It seems regrettable not to refer by name to T. H. Morgan whose work in genetics has been so important that it won for him the Nobel Prize some years ago. His work is reported, but the student will appreciate its importance the better when the above fact is known.

I feel sure that the many virtues of this book will make necessary new editions, and in these, those parts of the present volume that seem too heavy for student assimilation may be lightened as experience will indicate. *R.T.H.*

Butterflies

• *By* RALPH W. MACY and HAROLD H. SHEPARD, University of Minnesota Press, Minneapolis, 1941. 247 pp. $3.50.

Two professional entomologists, possessing an intense interest in the hobby of collecting butterflies, have combined their knowledge and experience to produce an excellent "Handbook of the Butterflies of the United States, Complete for the region North of the Potomac and Ohio Rivers and East of the Dakotas." Nature Study teachers and amateur lepidopterists will find the book extremely useful in identifying the species they collect because of the very satisfactory simplified keys, accurate descriptions, and numerous photographs. The book is surprisingly complete down to species, although subspecies are usually ignored. However, it is intended as an inexpensive guide for amateurs, and the professional taxonomists will, as always, find it necessary to refer to the larger and more specialized references. I cannot recommend this book too highly. I feel that it definitely fills the need for an inexpensive, but scientifically accurate, handbook of butterflies. *Ralph L. Chermock.*

* * * * Too often, the scientific worker is balked by the inadequacies of his method. If he is unable to see and overcome his obstacle to progress, he is destined to mimic and will never create. On the other hand, the more frequently he is able to cope with and conquer new problems, the more confidence he will have toward realizing the visions of his field. It is this attitude that makes for valuable, practical science.

—*Harold C. O'Brien.*

(From the Introduction to a Master's Thesis, Department of Biology, Duquesne University, August, 1941).

Light, Star Reporter

Continued from Page Sixty-eight

pulsations. The longer the time, the more luminous the star. Its absolute brightness, therefore, can be determined simply by measuring this time interval, other measurements having shown the brightness which corresponds to each interval. Knowing the brightness, the distance can then be found as before by comparing its apparent luminosity with that of a nearer star whose luminosity and distance are known.

Still another method can be used, in case the distance to one of the many pairs of twin stars is to be found. Such a pair of stars revolve about each other as if they were at opposite ends of a rod which connects them. By a spectroscopic measurement to be described later, the velocity of one of the revolving stars can be found. Knowing its velocity and the time it takes to move from one side of its orbit to the other, the diameter of the orbit is found by simply multiplying the velocity by twice the time and dividing by "pi." The angular distance across the orbit then is measured, which is the angle through which the telescope must be turned to move the cross-hair from one side of the orbit to the other. From this angle and the diameter of the orbit the distance to the star is found by simple trigonometry, as before.

Brightness or Luminosity

The apparent brightness or luminosity of a star is revealed to the eye or to the photographic plate by the number of photons which our reporter delivers from it each second. These photons vary a great deal in energy. Only those which represent a certain part of the spectrum affect the eye, while those representing a somewhat different spectral range affect the photographic plate. The brightness of the star, therefore, is not generally the same as recorded by the eye and by the plate. That is, the "visual magnitude" of the star usually differs from the "photographic magnitude," the "magnitude" being a measure of the brightness.

The intrinsic or absolute brightness varies greatly from one star to another. The most luminous star known emits one and one-half billion times as much radiation as the least luminous. The apparent brightness of the stars we can record photographically varies by approximately the same amount, if we do not include the sun, incomparably brighter than any other star because of its nearness. Since the apparent brightness decreases proportionately as the square of the distance of the star increases, many a star thousands of times as luminous as the sun is not visible to the eye, because of its great distance.

If the distance of a star is known, then its absolute brightness can be determined from its apparent brightness, using the law of inverse squares. From this law, the ratio of the absolute brightness of the star to that of the sun is equal to the ratio of their apparent brightnesses multiplied by the ratio of the squares of their distances from the earth.

Another method of determining the absolute brightness or luminosity has already been described in our discussion of the method of finding the distance of a variable star. There is a known relation between the rate of fluctuation of the star and its luminosity, so that if the former is known the latter can be found at once, as has been explained.

Chemical Composition

The vibrations which give a photon its energy result from something which happens in the atom from which the photon is ejected. Inside that miniature solar system are the planetary electrons, describing their orbits about the nucleus with amazing velocities. Sometimes their motions are violently disturbed. For example, an electrical particle or a photon of radiation, like a swift comet, may enter the system and strike an electron, throwing it into another orbit farther from the nucleus. When this happens, the electron takes on the quantum of energy of the photon which strikes it, and this is the energy it uses in moving to the higher orbit. But the arrangement is unstable, and when readjustment comes, our electron jumps back to its original orbit, giving up in the form of a photon the quantum of energy which it absorbed from the particle or photon which struck it. This quantum of energy varies in magnitude with the difference between the levels of the orbits. It varies also with the kind of atom of which the orbits are a part; and so each atom has an individual, characteristic spectrum formed by the photons which it emits, unlike the spectrum of any other kind of atom in the universe. The spectrum is the finger-print of the atom, the clue by which the scientist knows with certainty which of the ninety-two known kinds of atoms emitted the radiation.

Thus the astronomer is given a wonderful method by which he can discover the chemical composition of any star from which our star reporter brings vibrations. He needs only a spectrograph connected with his telescope and a knowledge of the spectral lines of each of the elements. The work of many physicists gives him that knowledge.

Stellar Temperatures

Everyone is familiar with the fact that as the temperature of a solid body rises it becomes first red then yellowish then bluish and finally so dazzling as to make judgment of color impossible. This shows that there is a relation between color and temperature. But where the eye gives only a rough estimate of the temperature, over a very limited range, the spectrograph gives more exact and extended information. Fitted with a device (for example, a thermopile) for measuring the total energy at different wave lengths of the spectrum, it gives us the spectral distribution of radiant energy. From the wave length at which the energy is maximum, the temperature of the body can

very easily be determined. Here we make use of Wien's Displacement Law, which states that the absolute temperature of a black-body (or perfect) radiator is inversely proportional to the wave length at which the energy is maximum. The temperature which we find in this way is, therefore, the equivalent black-body, or "effective," temperature. In the case of a star, this is not far from the actual temperature.

If we know the diameter of a star and its distance, we may find its temperature by another method. By means of a thermopile at the focus of the telescope we may measure the radiant energy brought by our star reporter each second to each square centimeter of the earth's surface. Call this energy E′. Then the energy E radiated each second from each square centimeter of the surface of the star is given by

$$E = \frac{d^2}{r^2} E',$$

where r and d are the radius and distance of the star, respectively. But E is proportional to the fourth power of the absolute temperature, T, by Stefan's Law, if the body is a perfect radiator. That is,

$$E = k\,T^4,$$

where k has the value 0.2885 if E is measured in ergs/cm.^{2}/sec. and T in degrees absolute. Knowing the value of E from the first equation, the second gives us the value of T, the effective temperature of the star.

Two other methods of determining stellar temperatures can be used. One is based upon the relation between the star's temperature and its "color-index," which is defined as its photographic magnitude minus its visual magnitude and is an approximate measure of the ratio of the amount of blue light to the amount of yellow light radiated. The other method is based upon the "bolometric correction," which is a measure of the ratio of the total radiant energy to the energy radiated in the visual spectrum.

These four methods give values which agree fairly well. So the astronomer can be confident that his calculated temperatures are reasonably accurate, although no thermometer has given him the answers.

Sizes of Stars

So far as the eye or a telescope alone can determine, a star is only a point of light with no diameter. True, it appears to have a diameter, but this is only an effect due to diffusion in the eye, spreading of the image on the photographic plate, and other slight optical imperfections. Even with their enormous sizes, in some cases greater than our entire solar system, stars are too distant to give images with measurable diameters. The simple and commonly used method of finding the diameter of an object from the diameter of its image, its distance and the focusing distance in the camera

or telescope, is therefore useless. We must interpret the vibrational evidence of our star reporter, evidence that is much more involved and complex than the mere angular separation of its rays.

If the distance of a star can be determined, and from this and its magnitude (brightness) the absolute magnitude found, the diameter of the star can be computed from a formula which expresses the relation between the diameter, the magnitude and the effective temperature. Certain constants in the equation have different values depending upon whether the magnitude is determined visually, photographically or bolometrically. The equation is based upon the idea that the energy of the radiation given out from the star is equal to its surface area multiplied by the energy radiated from each square centimeter of surface.

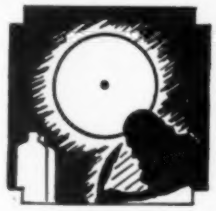
Michelson, the famous American physicist, devised a remarkable method of measuring the diameter of a star more directly. Two widely separated slits are placed in front of the telescope so that the light from the two slits combines to make interference fringes at the focus of the instrument. If light comes from opposite sides of a large star that is not too distant, the two sets of fringes that are formed are seen to overlap, and the amount of the overlapping can be used as a means of measuring the diameter of the star.

Velocities of Stars Relative to Earth

In describing the method by which the distance to a pair of revolving twin stars could be calculated, it was stated that by a specroscopic method the velocity of one of the revolving stars could be measured. Its velocity is determined in that part of its path where it is moving directly away from or toward the earth. Here a peculiar effect is seen. Our star reporter springs off into space from a body which is moving swiftly in the same direction or the opposite, like a man springing from a speeding train. But while the velocity of the man includes that of the train, the velocity of our celestial reporter is unaffected by the movement of the star. Only the length of its steps (its wave length) is affected, increased if the star is receding, decreased if the star is approaching. The position of each spectral line therefore is shifted, since the angle of deviation in the spectroscope varies with the wave length. The distance of shift, always small, gives a measure of the velocity of the star relative to the earth.

In this way it has been found that most of the nebulae are receding rapidly from the earth, with veilocities usually more than 1,000 miles per second and in some cases as great as 10,000 miles per second. The more distant the nebula, the faster it is moving away from us. It is as if we were in the midst of an "exploding universe" of stars.

But we can not be sure of this, for other explanations of the increased wave lengths are possible. Perhaps the photons lose energy by striking electrons or particles of star dust on their long journey to the earth. This would be in accordance with a well known phenomenon observed in laboratory experiments. Or perhaps our star reporter just gets tired—and who could blame him after a journey of some millions of years with never a second in which to rest or a single drop of refreshment to keep him vibrating properly. ●



"The swallows of San Juan Capistrano mission have become 'first page' news . . . because the press and publicity agencies somehow stumbled upon the rather obvious fact that human beings thrill to the wonders of nature — particularly when they seem to be connected, through legend or myth, with the even deeper wonders of the supernatural."

—*Michael Williams.*

☆ ☆ ☆

"Learn to read slow: all other graces
Will follow in their proper places."

—*William Walker.*

Catholic Physiographers

Continued from Page Eighty

strument, and constructed a telescope by means of which he made the first systematic investigation of sun spots.

Tempel, Wilhelm (1821-1889) discovered several nebulae and comets and published valuable star maps.

SCIENTIFIC LOCATIONS OF PLACES

LaPlace, Pierre Simon (1749-1827), played a great part in the scientific activity under Napoleon. He was an outstanding mathematical and physical astronomer and in the five volumes of his "Mécanique Celeste" produced a permanent monument to his own genius. The "Nebular Hypothesis" of the origin of the earth, gravitational effect of the sun and moon on the waters of the earth, the essential stability of the solar system, and other phases of physiography were treated with mathematical exactitude and clarity. He was an astronomer of the first magnitude and contributed not only to theoretical but also to the factual advancement of stellar knowledge.

Muller, Johann (1436-1476), Bishop of Ratisbon, computed a calendar with the location of the sun and moon, the eclipses and the dates for Easter for the next thirty years. He also established an observatory for the determination of astronomical constants and published astronomical literature. He secured the reform of the calendar.

Picard, Jean (1620-1682), was a French priest, one of the original members and the first president of the Academy of Sciences. The greatest service he performed for astronomy was to make the first accurate measurement of a degree of the meridian.

OCEANS

Balboa, Vasco Munez De (1475-1519), discovered the Pacific Ocean in 1513.

Borrus, Christopher (1583-1632), drew up the first chart of the Atlantic and Indian Oceans. He showed the spot where the magnetic needle makes the same angle with the meridian.

Columbus, Christopher (1451-1506), crossed the ocean four times after having discovered America in 1492. His letters and journals furnish detailed information about the sea and the lands he discovered.

Diaz, Bartolomeu (d. 1500), was a Portugese navigator who sailed the seas and discovered the Cape of Good Hope in 1488.

Gama, Vasco De (1469-1521), discovered a new sea route to India.

Magellan, Ferdinand (1480-1521), was a Portugese navigator who sailed westward and by the success of his expedition circumnavigated the globe and proved the world's rotundity.

Toscanelli, Paolo (1397-1482), was the astronomer and geographer to whose cosmographical knowledge, and especially to whose charts of the oceans, Columbus largely owed the discovery of America.

Verrazano, Giovanni, De (1485-1527), crossed the Atlantic Ocean, explored the coast of North America and is hailed by his Italian countrymen as the discoverer of the Hudson River.

RIVERS AND GROUND WATERS

Cartier, Jacques (1491-1557), French explorer discovered Canada in 1534. He explored the coasts of Labrador and Newfoundland and ascended the St. Lawrence River to Montreal.

De Soto, Hernando (1496-1542) Spanish explorer, discovered the Mississippi River in 1541.

Joliet, Louis (1645-1700), French Canadian explorer, was associated with the work of Marquette along the Mississippi River.

La Salle, Rene Robert Cavalier, Sieur De (1643-1687), French explorer, discovered the Ohio River and explored the valley of the Mississippi River.

Marquette, Jacques, S. J. (1636-1675), explored the Mississippi River in 1673, and left valuable notes and maps in his diary.

Orellano, Francisco De (1500-1543), a Spanish navigator, discovered the course of the Amazon River.

LAKES

Champlain, Samuel De (1570-1635), French explorer, discovered Lake Champlain. He is the "Father of New France" and founder of Quebec.

Hennepin, Louis (1640-1701), was a Franciscan who discovered Niagara Falls, explored the Great Lakes region and followed the Mississippi River to its mouth.

Neckam, Alexander (1157-1217), an Augustinian scholar, was Abbot of Cirencester, England. His "Liber de natura rerum" contains the earliest record of the use of the mariner's compass in navigation, and a list of remarkable springs and lakes.

GLACIERS

Hubbard, Bernard, S. J., the "Glacier Priest," was born in San Francisco, California in 1888. He is Professor in Geology at the University of Santa Clara, California, and since 1926 has made annual expeditions to Alaska to explore and to photograph with motion picture cameras the Valley of the Ten Thousand Smokes, Mt. Katmai, Mt. Aniakchak, etc. He is an authority on glacial phenomena.

Dutilly, Pere Artheme, O. M. I., an Oblate of Mary Immaculate is another priest-scientist engaged in research in the frozen regions of the Arctic. His interest is devoted more especially to the flora of the Arctic regions. Pere Dutilly's arctic trips have taken him along the Arctic coasts of Canada, around Labrador, in Baffin Land, on the Keewatin peninsula, across the long coast of the Northwest territories, up the Mackenzie and Slave Rivers. He is an authority on Arctic botany.

SHORE LINES AND HARBORS

Newton, John F. (1823-1895), General, U. S. N., was an authority on harbors and performed excellent work on the harbors of Boston, and New York. He improved

navigation in and about New York State, especially in Hell Gate Channel opposite the east side of upper Manhattan.

ATMOSPHERE, WEATHER, CLIMATE

Algue, Jose, S. J. (b. 1856), was a Spanish Jesuit-scientist who invented the barocyclonometer used to detect the approach of cyclones.

Cecchi, Philip (d. May, 1887), was an Italian meteorologist who belonged to the Piarist Order. His researches were concentrated mainly on the storms of Italy, the zodiacal lights, and seismic disturbances.

Denza, Francesco (1834-1894), a Barnabite, did notable photographic research work on the heavenly bodies. He was instrumental in establishing over 200 meteorological stations in Italy, rebuilt the Vatican Observatory, and engaged deeply in meteorological research.

Heinrich, Placidus Joseph, O. S. B. (d. 1825), was a Benedictine priest-scientist of St. Emeram whose contributions to the climatology of the Danube Valley are of the highest value.

Le Verrier, Urban (1811-1877), made the mathematical discovery of the planet Neptune and computed the orbits of Mercury and Uranus. He founded the International Meteorological Institute, and organized the French Weather Bureau Service.

Secchi, Angelo, S. J. (1818-1878), Italian astronomer, Professor at Georgetown University, invented the meteorograph, an instrument for the automatic registration of meteorological phenomena, made important measurements of double stars, and extensive spectroscopic classification of the five stars known by his name. He laid the foundation of the unique "Sun Records" and discovered the "Flash Spectrum." ●

"A teacher who can arouse a feeling for one single good action, for one single good poem, accomplishes more than he who fills our memory with rows on rows of natural objects, classified with name and form."

—*Goethe.*

The World of Color

Continued from Page Seventy

In nature, the sun is our main source of light and color. When its white light falls upon any object, usually a part of the light is reflected, part transmitted, and the rest absorbed. If the object reflects most of the sunlight, we say the object is white. If it absorbs most of the light and reflects nothing, we say the object is black. If the object reflects mostly the red rays of the spectrum and absorbs the rest, we call the object red. In general, it is the selective process of reflection which by modifying the incident light determines the color of an object. We may think about the surface of an object as a "color mirror" that has the property of reflecting some particular variety of wave lengths. It must always be remembered that originally all these colors must be present in the source itself.

We are fortunate, indeed, that our main source of illumination, the sun, is so rich in its variety of colors. Without it, if it were like the previously demonstrated sodium vapor lamp, our world would certainly appear drab. We might also mention that the sun brings to us not only color but also heat and those benevolent ultra-violet rays without which the life on our little planet would be impossible. If we had to pay for all the energy we receive from the sun, even at the very cheap rate of one cent per kilowatt-hour, our bill would be $500,000,000 for each second of sunlight.

In the accompanying Figure this threefold process of color perception is represented by a simple diagram. ●

REFERENCES:

1. This substance can be purchased from the Eastman Kodak Co.
2. Sir William Bragg, *The Universe of Light*, p. 101.

National Essay Contest

Continued from Page Sixty-five

quired that the student shall be enrolled at present in any science course. Catholic students attending public high schools may not compete.

2. Each school may submit *only one* essay.

3. Essays should be typewritten, double-spaced, with good margins, on one side of the sheet only. Legible hand-written manuscripts may be accepted. Essays are to be in essay form. They may not exceed 1,200 words in length. Longer essays will be rejected without reading. All direct quotations must be inclosed in quotation marks and references given. Long quotations are not acceptable. Essays may not be illustrated nor accompanied by charts or exhibits.

4. Each essay shall be the individual work of the student. In its final form it may receive only such supervision as is given in the usual written examinations of the school.

5. A plain, sealed envelope, firmly attached to the essay, must contain the full name, age, and home address of the contestant, the actual number of words in the essay, the name and address of the school, and the name and title of the supervising teacher. No further identification of the writer or the school may appear on the essay or the envelope.

6. Essays must be forwarded by the principal or the supervising teacher with the statement that the essay was written under supervision and that it is the original work of the student.

7. Essays for this contest must be mailed to the Director of the Science Conference, Duquesne University, Pittsburgh, Pa., not later than *February 1, 1942*. Essays will not be returned. ●

Physical Science

Continued from Page Eighty-two

B. Directions. Mark the following statements plus or zero to indicate whether they are true or false.

A person whose attitudes may be characterized as "scientific"

71.____ believes his own desires, tastes, beliefs, and experiences are safe guides to conclusions;
72.____ never makes tentative conclusions, but waits until the evidence is complete;
73.____ believes that Truths once discovered are final, complete, and never-changing;
74.____ is willing to accept the findings of other reputable authorities;
75.____ believes that "what you don't know won't hurt you";
76.____ believes only what he wants to believe;
77.____ is not afraid to ask questions even though he may not like the answers;
78.____ believes in cause and effect—that there is a cause for everything that happens;
79.____ has great faith in the trial and error method of solving problems;
80.____ is necessarily lacking in religious attitudes.

C. (This test item is based on one given in Hawkes, Lindquist, and Mann, *Achievement Examinations*, pp. 248-249). In an experiment, coal gas which had not been mixed with air was burned at a gas jet. At another similar gas jet, coal gas was mixed with air before it was burned. Identical aluminum pans containing equal amounts of cold water were placed over the flames. The experimenter noticed that:

a. There was more light given off at the first jet than at the second;
b. A deposit of soot accumulated on the bottom of the pan at the first jet;
c. The water in the pan at the second jet reached its boiling point first.

What do these results mean? In the space before each of the following statements, write a figure

1—if the statement seems probably true because it agrees with or is supported by the experimental evidence;

2—if the statement is probably false because it is contradicted by the experimental evidence;

3—if the statement cannot be judged as either true or false because the experimental evidence is incomplete.

81.____ The amount of air admitted to a flame has no effect on the nature of the burning.
82.____ The amount of air mixed with a gas that is burned has no effect on the amount of light the flame produces.
83.____ Burning was more complete in the second flame than the first.
84.____ Incomplete combustion leaves some free carbon in the flame.
85.____ The amount of light produced by a flame is regulated by the amount of free carbon in the flame.
86.____ If a gas flame deposits soot on cooking utensils, the flame should be regulated in the interest of increased economy.
87.____ A yellow flame that deposits soot is just as good as one that does not deposit soot, if you don't mind cleaning the smoked-up pans.
88.____ The burning at the second jet is more likely to produce carbon monoxide than the burning at the first jet.
89.____ The amount of light energy plus the amount of heat energy produced at each jet is the same.
90.____ The amount of water vapor formed as a product of combustion is the same at both jets. ●

Mathematics and Chemistry

Continued from Page Seventy-one

This development has taken place so fast that the training of chemists in mathematics has not kept pace. Inadequate preparation in mathematics now constitutes the greatest problem in the teaching of physical chemistry.

The following quotations support these statements: Crum Brown stated in 1892: "Unless the chemist learns the language of mathematics, he will become a provincial and the higher branches of chemical work, that require reason as well as skill, will gradually pass out of his hands."

After quoting this statement, James Kendall goes on to say:

"Such a statement, regarded then as sensational, would now pass unnoticed as a platitude. Whether or not he likes it, every physical chemist of the present time must also be a mathematician. The actual amount of formal mathematics which it is essential for him to assimilate is not large, but he must be able to use every particle of it with a clear understanding."

In emphasizing the mathematical weakness of chemical training, J. R. Partington says: "Exactly why the student of chemistry is always assumed to have much weaker equipment than other students is difficult to say, but the fact remains that it is always customary to proceed on this assumption, and to take care that when his delicate constitution is to be subjected to small doses of mathematics, these are always well diluted with neutral matter."

Speaking of the older physical chemistry, E. W. Washburn remarked that it was customary to . . ."adopt a somewhat apologetic attitude, and to explain that the student must take on faith these few mathematical derivations, but that he should not allow this fact to worry him." He goes on to say that, in a modern course in physical chemistry . . ."calculus is freely employed and the student is strongly advised to acquire the elements of calculus before attempting to secure any special training in physical chemistry."

Pointing out that freshman chemistry now embraces physical chemistry as it given a generation ago, H. S. Taylor states that in place of the older descriptive qualitative course physical chemistry offers a more rigorous, and therefore, more mathematical discipline. He believes that any teacher who advises his students that they can attain to an understanding of the science, as now developing, without mathematical knowledge, is doing an ill service to his pupils.

Professor T. W. Richards has said: "I am a thorough believer in sound mathematical treatment and I feel that positive knowledge is not available until one has a satisfactory mathematical expression of his problem. Such a viewpoint . . . is entirely consistent with profound mistrust of mathematics based upon inadequate premises."

The task of the mathematical chemist is, indeed, more difficult than that of the mathematician for the test tube imposes many restrictions that are unknown to the pure mathematician. The student must be able to juggle algebraic formulas, and put them into the form which is necessary for any particular purpose. He must be able to solve quadratic equations. The ability to handle large and small numbers is essential, because important advances are now being made by visualizing the individual units of matter, electricity, and radiation.

Logarithmic equations are extensively used by the chemist, but the physicist usually employs exponential equations. The student of physical chemistry must be able to solve either, and he must be able to transform one into the other. Negative logarithms are encountered frequently in electrochemistry, particularly in the treatment of hydrogen-ion concentration.

The finding of an empirical equation for a set of data is an important art. Experience in curve fitting in analytical geometry would be welcomed by the chemist. The student is much impressed when he obtains data in the laboratory (for example, the vapor pressure of a liquid at different temperatures) plots a curve, finds its equation, and then finds that the empirical constants can be derived from theoretical considerations.

Calculus is absolutely essential. Simple differentiations, integrations, integration between limits, and the use of integration tables, are all necessary. As a rule, the ordinary college preparation in calculus is sufficient to meet the demands of physical chemistry, but students seem to lack confidence. The cause is not easy to understand. It may be that the instructor in chemistry himself lacks confidence, or it may be that the student thinks that the chief aim of calculus is to memorize half a hundred rules of differentiation and integration. The teacher of physical chemistry does not expect that the students will remember many of these rules, but he does want them to understand the principles, and to be able to think in terms of calculus.

The compound interest law runs through many branches of physical chemistry, and it should be clearly understood. Differential equations are used frequently, but usually they are so simple that the student does not realize that he is solving differential equations. When several reactions are proceeding simultaneously, more complicated differential equations are needed.

We have outlined briefly some of the mathematical requirements for a course in physical chemistry. The question now arises as to how these requirements shall be met. Obviously, there is only one satisfactory answer. The student must have had courses in mathematics through integral calculus before he is permitted to take physical chemistry. It is to be hoped in this connection that the courses in mathematics will include, along with the problems for engineers, some problems especially for chemists, and that some phases of the mathematical training which are of special importance in chemistry will be stressed a little more than is usually done. The most important contribution of mathematics, however, is not concerned with any specific technique; it is a mathematical state of mind. That is acquired only after long practice in solving problems.

We have stated that inadequate preparation in mathematics is the most serious difficulty in the teaching of physical chemistry. In concluding our discussion, a still stronger statement, made by Farrington Daniels of the University of Wisconsin, may be quoted: "Inadequate experience in mathematics is the largest single handicap to the progress of chemistry in America." ●

Synthetic Rubber

Continued from Page Seventy-three

Through the establishment of a corporation sponsored jointly by the Reconstruction Finance Corporation and American rubber companies, contracts have been made for the direct purchase of an additional 150,000 tons in 1940, and 180,000 tons in 1941 as a wartime measure, and this material is now coming in at a good rate.

Should the supply of crude rubber be cut off, or should the threat of interference with regular shipments become imminent, the synthetic rubber industry will obviously face an entirely different situation than the one which now exists. Instead of being a specialty product as at present, synthetic rubber would then have to supplement our available supplies of the natural product in the form of manufactured goods, crude and reclaim.

That this must be so becomes evident from a consideration of two facts: first, that our climate is not suitable for the growing of rubber trees; and, second, that if efforts were made to increase South American production, some 8-10 years would be required before the new plantations would reach the producing stage.

In attempting to answer the question as to how such an eventuality could be met, it is important to note that the production of synthetic rubber is no longer in the experimental stage. It already forms the basis of a substantial industry. Moreover, through its work in the specialty field, the American rubber industry is thoroughly familiar with the processing of synthetics and would therefore be in a position to adapt itself to their wider application. On the other hand, it must be recognized that a more extensive change to synthetics, based on our present knowledge, would work a considerable hardship on the rubber industry. Because of the greater toughness of many of the synthetics, production would undoubtedly be slowed up, for a while at least to a point where some equipment expansion would be required.

The various synthetic rubbers have already been tested extensively in uses for which they have not as yet found a general application because of price considerations. While they may be more difficult to process by conventional factory methods, we know that some of these products can be built into tires which are equal to, and in some respects even superior to, those made from natural rubber. By way of illustration, Buna S has been found to give wear equivalent to that of the best rubber tire treads. Under the best conditions of both compounding and service, Perbunan has proved to be a 10-20 per cent better. Neoprene is reported to give results the full equal of those obtained with Buna S.

The synthetic rubber industry has already developed to a point where plant capacity should be available next year for the production of at least 50,000 pounds a day, and possibly a good deal more. Impressive as such figures are, they represent only some two per cent of our crude rubber imports. This indicates that there is considerable room for expanding production as manufacturing costs are lowered and new products are developed with a resulting widening field of application. It is generally agreed that facilities for replacing a substantial portion of the country's consumption of natural rubber could be installed within two years. Such considerations lead to a rather optimistic view of the situation. It would seem that by judicious planning, the American chemical industry can in time meet any emergency which may presently be foreseen in the rubber field.

It is of course true that the various synthetic rubber processes would require a correspondingly adequate supply of raw materials or chemical intermediates. This situation, however, can be fully met by expansion of known processes. It so happens that all the basic materials involved, even in those cases where they are not being presently derived from this source, are potential petroleum derivatives. For this reason, it is of interest to note that, on a weight basis, our annual import of crude rubber is only about one-third of one per cent of the crude oil produced. Clearly, then, there need be no concern over the question of raw material for supplying any reasonable demand for rubber via the synthetic route. ●

REFERENCES

Frolich, P. K., *News Ed., A.C.S.*, **18,** page 285 (1940).
Murphree, K. V., *J. Ind. & Eng. Chem.*, **32,** No. 9, p. 1203, Sept., 1940.
Street, J. N., Paper presented before the Rubber Division at the Detroit Meeting of the A. C. S., 1940.
Wood, L. A., Circular of the National Bureau of Standards C-427, June 29, 1940.

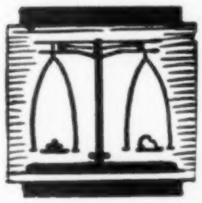
Growth by Cell Enlargement

Continued from Page Sixty-six

It furnishes the "trigger energy" in the protoplasm which causes significant changes in the wall and the production of osmotically active substances which are stored in the cell sap cavity and cause the influx of water. Some of the material stored in the protoplasm itself is probably used up, which accounts for the significant changes described by Strugger. The changes are really changes in the ionization. This would correspond to the changes referred to by Klebs, Grafe, and Borowikow. The active protoplasm causes a change in the nature of the cell wall which becomes plastic or ductile as was claimed by Klebs, Laurent, Ziegenspeck and Went.

In the earliest stages the pressure on the inside is almost entirely due to the imbibition of water in the protoplasm since not much solute is present in the cell sap cavity. Later, as the amount of solute increases with the growth, the hydrostatic pressure becomes greater and stretches the wall while it is sufficiently young and plastic. Still later when the walls are less plastic and more resilient the walls are stretched but not beyond the limits of elasticity and they set up a counterpressure to the turgor. Beginning with this stage, the growth rate and the rate of solute production decline and the walls become more rigid as the cells approach maturity. Mature cells have relatively low suction tension, high turgor and high wall pressure and growth by cell enlargement has practically ceased.

Basing ourselves on experimental evidence and upon logical deductions from these, the conclusion is justified that growth by cell enlargement, like any other form of growth, must be regarded as a physiological process. ●



Balancing Equations

Continued from Page Seventy-seven

3. The valence of O is always taken as negative 2.
4. The valence of a free element equals zero.
5. There are exceptions to these general rules.

Balancing these equations consists in equalizing the apparent gains and losses in valence, and in adjusting the atoms of the other elements involved so that the number of atoms of each element shall check as in an ordinary algebraic equation. We readily see that the matter of adjustment is not scientifically worked out.

Applying this method to the equation used before:

$$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$$

On the left hand side of the equation: Cu has a valence of O; H has a valence of $+1$; N has a valence of $+5$; O has a valence of -2.

On the right hand side of the equation: Cu has a valence of $+2$; H has a valence of $+1$; N has a valence of $+5$ and of $+2$; O has a valence of -2.

It is evident that Cu and some of the N change in valence. Cu increases 2, and part of the N decreases 3; therefore, to equalize the gain and loss in valence we must multiply the Cu by 3 and the HNO_3 by 2. This done, we turn to the right hand side of the equation and multiply the $Cu(NO_3)_2$ by 3 and the NO by 2. Here we find the unscientific part of this process: we "juggle" to get enough HNO_3 to give us the NO_3^- radicals for copper nitrate and the hydrogens for the water formed by the release of oxygen in the formation of NO. Obviously the method needs refinement.

Ion-Electron Method

After working with the valence-change method it is a real pleasure to learn the ion-electron method. This method which involves the use of ionic equations, teaches the student to remember the ionic nature of most compounds. It introduces the hydronium ion concept, which also should be used by the student. The method is free from hypothesis regarding the distribution of valence bonds among the individual atoms in such ions as MnO_4^- an NO_3^-.

The first step in balancing an equation by the ion-electron method is resolving the reaction into an ionic equation.

$$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$$

becomes

$$Cu^\circ + H^+ \cdot H_2O + NO_3^- \longrightarrow Cu^{+++} + 2NO_3^- + NO + 2\ H_2O$$

The equation is then divided into two partial equations, one of oxidation and the other of reduction:

O. $Cu^\circ \longrightarrow Cu^{++}$

R. $NO_3^- + 4H^+ \cdot H_2O \longrightarrow NO + 6\ H_2O$

These partial equations are balanced so far as atoms are concerned, but since they are ionic equations they must be balanced electrically. We know that when an atom or radical increases in positive valence there has been a corresponding loss of electrons; when it decreases in positive valence or increases in negative valence there has been a corresponding gain of electrons. Therefore, to balance the two partial equations electrically we write them:

O. $Cu^\circ - 2\ e \longrightarrow Cu^{++}$

R. $NO_3^- + 4\ H^+ \cdot H_2O + 3\ e \longrightarrow NO + 6\ H_2O$

In any complete equation involving a transfer of electrons the gain and loss must be equal; so we must multiply the **O** equation by 3 and the **R** equation by 2. This gives us:

O. $3\ Cu^\circ - 6\ e \longrightarrow 3\ Cu^{++}$

R. $2\ NO_3^- + 8\ H^+ \cdot H_2O + 6e \longrightarrow 2\ NO + 12\ H_2O$

Adding the two equations algebraically we arrive at the equation:

$$3\ Cu^\circ + 2\ NO_3^- + 8H^+ \longrightarrow 3\ Cu^{++} + 2NO + 4\ H_2O$$

The eight molecules of water due to the hydration of the hydrogen ion are omitted in this and in the final equation since water is the medium in which the reaction is taking place. This ionic equation shows the minimum quantities of reactants and products needed to balance the final equation. The only ion not shown is the NO_3^- which deos not undergo any change. This is automatically taken care of when the rest of the equation is balanced. So we write as our final equation:—

$$3\ Cu + 8\ HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4\ H_2O$$

This method applied to ionic equations is devoid of assumptions. The partial equations are not imaginary. They represent the half reactions which actually take place when these same solutions in different vessels with inert reversible electrodes and a connecting salt bridge are permitted to react. The electrons will flow from the cell containing the reducing agent to that containing the oxidizing agent in amounts predicted by the equations.[4] Applied to another type of equation, the method is purely mechanical. As a teaching tool it seems to have much in its favor, certainly far more than any other method used at the present time. ●

BIBLIOGRAPHY

1. Deming, H. G., *Journal of Chemical Education*, Vol. 11, p. 125 (1934).
2. Barthauer, G., *Journal of Chemical Eductaion*, Vol. 17; p. 91-92 (1940).
3. Johnson, O. C., *Chemical News*, Vol. 42; p. 51 (1880).
4. Foster, L. S., *Report of the New England Association of Chemistry Teachers*, Vol. XLII; p. 79 (1940).